LEARNING STRATEGIES AND ACHIEVING SKILLED PERFORMANCE

By

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It was the purpose of this study to compare the effectiveness of three learning strategies on achievement in two different self-paced motor tasks. More specifically, investigated was the influence of (1) an awareness strategy (to use kinesthetic cues, be aware of the task, and think about the act), (2) a nonawareness strategy (to preplan the action and perform the task without conscious attention to it), (3) Singer's Five-Step Approach (readying, imaging, focusing, executing, and evaluating), and (4) a control condition (no strategy) on the acquisition of skill in ball-throwing and key-pressing tasks.

In Experiment 1, 72 subjects were randomly assigned to the four conditions. One hundred and twenty-five trials were administered for the ball-throwing task on Day 1. During Day 2, subjects completed 125 more ball-throwing trials followed by 50 trials in a dual-task performance situation (the throwing task and a verbal task). Separate analyses of variance with repeated measures were used to analyze absolute constant error (ACE), variable error (VE), and number of bull's-eyes for the ball-throwing task, and number of errors for the verbal task.

The same learning strategy conditions were administered in Experiment 2. Sixty-four subjects completed 250 trials in an attempt to master a key-pressing task and 50 trials in a dual-task performance situation (the key-pressing task and a verbal task). ANOVAs were conducted to analyze response time, movement time, reaction time, and number of errors for the key-pressing task, and number of errors for the verbal task.

Similar results were observed in both experiments. The three learning strategy groups performed better than the no-strategy group in the acquisition phase as well as in the dual-task situation. Among the learning strategy groups, the Five-Step Approach and the nonawareness subjects achieved better than subjects in the awareness group. It was concluded that task-pertinent strategies enhance motor task performance. Additionally, it appears that novices can learn and perform better when they use strategies that are apparently used by skilled performers.

CHAPTER 1

INTRODUCTION

Research in motor learning has provided useful guidelines for individuals as to how to control movements, and how to learn motor skills (Schmidt, 1988, 1991; Singer, 1980a). Although clear-cut answers to some relevant questions about effective practice conditions have not been provided yet, it seems that research is abundant for many considerations related to teaching and learning motion acts.

Some examples are (a) the ideal distribution of practice, such as massed versus distributed practice (Adams, 1964; Lee & Genovese, 1988, 1989) and blocked versus random practice (Magill & Hall, 1990; C. H. Shea, Kohl, & Indermill, 1990; J. B. Shea & Morgan, 1979); (b) the amount and timing of knowledge of results given to learners during or after performance (Lee & Carnahan, 1990; Salmoni, Schmidt, & Walter, 1984); and (c) the role of the teacher/instructor in terms of setting goals, modeling and demonstrating the desired task, and providing instructions and directions (Gentile, 1972; McCullagh, Weiss, & Ross, 1989; Singer, 1980a). Both teachers and learners should find this information to be useful for their particular needs.

However, many guidelines found in motor learning research are more appropriate to teachers than to learners. Teachers use this information to design practice situations in which learners can acquire skills related to the content of the activity. In a typical learning situation, after formal instruction (e.g., as in the school) is completed, students would undertake the activity on their own, independent of supervision. They may have to adjust to new conditions. They would need to transfer previous knowledge and skill to new related learning situations as well as to cope with demands not experienced previously.

To anticipate future needs of students, it seems that instructors need to pay more attention to enhancing the effect of learning processes and appropriate strategies during formal instructional programs. Behaviors and thoughts that learners should use during acquisition, and that are intended to influence information processing processes, should be taught by instructors (Weinstein & Mayer, 1986). By directing learners in the use of task-relevant strategies, teachers can help them to activate appropriate cognitive processes and at the right time. Ultimately, and ideally, students would know more about how to manage their own cognitive processes and to analyze themselves and situational demands in order to perform well.

In educational psychology, an emphasis on cognition and human information processing has lead to research on effective learning strategies, and how these strategies may be taught to individuals who do not use them spontaneously. The prominent finding that has emerged from these studies is that cognitive and metacognitive strategies enhance learning (Garner, 1990). Learners apply cognitive strategies to make progress, and they apply metacognitive strategies to monitor that progress (Flavell, 1979; Peverly, 1991). It has been shown that such skills as reading (Derry & Murphy, 1986), writing (Good & Brophy, 1990), and memorizing lists of words (Flavell, 1971) can be enhanced through the activation of such cognitive strategies.

Although motor skills appear to be acquired in a manner similar to cognitive skills (Anderson, 1982, 1987; Crossman, 1959; MacKay, 1982), most motor learning researchers have neglected research on learning strategies. However, Singer and his colleagues (cf. Singer, 1988; Singer, Flora, & Abourezk, 1989a; Singer & Suwanthada, 1986) have shown interest in this area by studying the effects of a global learning strategy, termed the Five-Step Approach, on the learning and performing of motor tasks (e.g., key-pressing and dart-throwing). The Five-Step Approach is based upon research on the sub-strategies incorporated in this technique as well as on anectodal evidence. The evidence indicates that when subjects have been taught the strategy they performed better in primary and related tasks than subjects not taught to use any particular strategy.

Other types of task-relevant strategies besides the Five-Step Approach could presumably enhance the learning and performance of various motor tasks. As one possible paradigm for determining desirable strategies, learners could attempt to determine how experts approach performance, and what they think about during execution. By understanding what highly skilled experts do, beginners might attempt to apply similar strategies.

In sport settings, skilled athletes typically have reported, following a contest, that they did not pay attention to what they were doing when they executed at their best. They seemed to perform without awareness. They were relaxed and presumably let the movements flow. The movements appear to be exhibited as if the athlete was in a state of automaticity, executing without any conscious attention. In contrast, beginners consciously try to attend to environmental cues and specific details during the act. They attempt to be aware of what they are doing. In most instructional settings, beginners are usually taught to think about the execution of the movements, and how or when to use movement-produced feedback.

A logical question is whether beginners need to or should follow the conscious awareness approach in the process of developing higher-order skill, or whether they should attempt to block thoughts during performance and attempt to execute as if automatically, as experts do.

On the one hand, when learners are typically instructed how to acquire skill, they pay attention to what they are doing, and think about the act. Furthermore, instructors often demand active thinking during performance. According to Gagné (1985), instructors set teaching objectives to develop learners' awareness of their performance while directing them to acquire a new skill. Ravizza (1986) added that coaches lead athletes to gain control during performed activity by asking them to be aware of their previous best performance, emotional state, and arousal level. Additionally, Feldenkrais (1972) postulated that learners need to think about the way that they move their body to control movements. By paying attention to details during the learning process, it is believed that learners feel in control, and thus they are able to demonstrate the skill better.

On the other hand, in the advanced stage of learning, individuals can perform without deliberately thinking about what they are actually doing. They are able to preplan their actions, focus their attention on specific cues, and perform as if in a state of automaticity. Practice enables them to control their performance without continuous cognitive monitoring. Putting it simply, "things just seem to happen" (Garfield & Bennett, 1985, p. 181).

An example of a strategy that presumably can be (and should be) activated by both beginners and advanced performers is the Five-Step Approach (Singer, 1988), described earlier in this chapter. This technique has been suggested for use in the learning and performing of self-paced activities, such as serving in tennis and shooting foul shots in basketball. In such events, there is time to preview the situation, to get ready, and to execute in a stable and predictable situation. The Five-Step Approach was originally conceived on the basis of research on the component sub-strategies, as well as experiences with beginners and experts in sport settings.

Implementing the strategy involves five steps (e.g., readying, imaging, focusing, executing, and evaluating). In the first two steps, individuals are asked to (1) be ready mechanically, attitudinally, and emotionally to perform well and (2) imagine themselves successfully executing the movement. In the last three steps of the strategy, they are guided to (3) focus their attention on specific cues to block out any distractors, (4) perform without thinking about the movement or the outcome, and (5) evaluate their performance if time permits. In the last case, they would evaluate their performance as well as determine if each step of the technique was effectively used in the performance of the skill.

The five sequential steps of the strategy provide useful information to learners on how to (a) prepare themselves to do the task, (b) approach it during execution, and (c) evaluate their own performance. Among these, there are steps in which thought processes and awareness of what needs to be done are required, as in the first and second (readying and imaging). Individuals are directed to think of the coming event and to pay attention to specific readiness details. For example, a table-tennis player, while ready to serve the ball, may be aware of his/her expectancies, arousal level, ready position, posture, and the way that he/she holds the ball and the racquet. A routine pre-act performance can be established to manage these considerations. This would be followed by imaging the expected performance of the act (e.g., the serve). However, according to the Five-Step Approach, while actually serving the ball, no thoughts should be directed to the act. That is, the serving should be performed as if automatically.

Evidently, the Five-Step Approach directs individuals to consciously attend to mental and psychological preparation factors, whether during learning or performing with a high level of skill. However, such preparatory routines probably become somewhat automatic with proficiency in a task. Nonetheless, preparatory awareness is associated with how beginners are typically instructed. In addition, with the Five-Step Approach, all performers are oriented to execute without thinking about the act as experts seemingly do during performance. Thus, awareness and nonawareness are components of the Approach. However, it may be more effective, and more simple, to emphasize only one orientation. For example, learners can be directed to be aware of themselves, the task, and the situation in the fourth step (the execution phase) as they are during the first three preparatory steps. In contrast, they may be guided in the readiness phase to approach the act with minimal cognitive involvement, as they would do in the fourth step. In other words, an argument could be made for the use of an awareness strategy, a nonawareness strategy, or the Five-Step Approach in learning situations involving self-paced motor skills.

In this context, if the awareness strategy represents a beginner approach, the nonawareness strategy reflects an expert's thoughts and behaviors during execution, and the Five-Step Approach combines both awareness and nonawareness components (with an emphasis on the nonawareness mode during performance), three orientations toward learning and performing an act can be observed. In the first, novices may follow traditional instructional programs. They would be guided to think about what they are doing, and to be aware of what needs to be done before as well as during execution. In other words, they would use the awareness approach to learning and performance. In the second route, beginners may approach the task as experts do. They would be given, for example, task-instruction and directions on how to execute. Then, they would be taught to do the act without paying attention to the task, situation, or the outcome of it. Apparently, they would use the nonawareness strategy. A third possibility is the Five-Step Approach to learning and performance, which combines elements of the other two strategies. It is also more elaborate, time-consuming to teach, and more difficult to comprehend completely as compared to the other two strategies. Consequently, there are apparent advantages and disadvantages to it.

Thus, the leading question which should be asked based upon the available research on learning/performance strategies, and observations of novices and experts as to how they approach their tasks is: Can novices approach the learning and performing of motor tasks the same way as experts do? In other words, can beginners effectively use expert strategies (e.g., the nonawareness strategy or elements of the Five-Step Approach) to their advantage? It seems that beginners who use strategies followed by experts should achieve at a higher level, as well as more efficiently in the use of practice time. However, are they capable of adopting this approach?

Therefore, the primary focus of this study was to determine the effectiveness of alternative strategies on the learning of two different self-paced motor skills. The strategies were the Five-Step Approach, (which includes awareness and nonawareness components), an awareness strategy (typical beginner strategy), and a nonawareness strategy (typical expert strategy) on the attainment of skill. An attempt was made to determine if any particular strategy lead to a greater level of skill, and a sense of performance automaticity.

Statements of the Problem

There were three primary purposes for conducting this investigation: (1) to compare the influence of three different learning strategies (awareness, nonawareness, and the Five-Step Approach) on the learning of a ball-throwing task and a key-pressing task; (2) to determine the degree to which the effects of the strategies are similar across the two tasks; and (3) to examine the effectiveness of the strategies on primary task achievement when a dual-task performance situation is introduced.

Hypotheses

The following research hypotheses were tested:

1. While performing the ball-throwing task (Experiment 1) and the key-pressing task (Experiment 2), subjects using the learning strategies (awareness, nonawareness, and Five-Step Approach) would achieve a higher level of skill than the control group (subjects not guided by any specific strategy). It was expected that the strategy group would produce less absolute constant error (ACE) and variable error (VE) for the ball- throwing task, and faster reaction

time (RT), movement time (MT), and response time (TT) for the key-pressing task.

When subjects use relevant strategies, cognitive learning (Derry, 1983; Derry & Murphy, 1986; Kurtz & Borkowski, 1984) and motor learning (Singer, DeFrancesco, & Randall, 1989; Singer & Suwanthada, 1986) have been improved. These and other studies have generally indicated that (1) control and self-confidence were increased, (2) knowledge was transferred from one learning situation to another, (3) new learning requirements were coped with better, and (4) skill level was enhanced. In addition to these observations, beginners tend to select, acquire, organize, and integrate new knowledge more effectively (Weinstein & Mayer, 1986).

In the current investigation, all three learning strategies contained elements that might assist learners to achieve a higher level, particularly the Five-Step Approach, which has been investigated in other studies (e.g., Singer, Flora, & Abourezk, 1989a). (Research is lacking on the other two strategies, although there is logic in the use of either one.) Hence, subjects using the specific directions for the awareness, the nonawareness, and the Five-Step Approach strategies would achieve better than subjects who would not direct to apply any particular strategy.

2. The nonawareness strategy condition would lead to better performance than the awareness condition, which in

turn would lead to greater success than the control condition. There were two main reasons for these predictions. First, during peak performance, skilled athletes have reported that they were not aware of what they were doing. Skilled movements seemed to occur without thinking about oneself, the situation, and the opponent, or paying attention to details (Garfield & Bennett, 1985; Loehr, 1990). It seemed that the event was performed as if the person was in a state of automaticity, and skill was demonstrated subconsciously.

Second, if learners were asked to pay attention to cues and to think about what they were doing, then attention might be shifted from one source of information to another, and even divided among several, perhaps irrelevant sources. In addition, the over-attention to environmental and self-cues during performance might be overwhelming and consequently might affect achievement adversely.

In this study, the nonawareness group approached the learning situation as experts seemingly did. However, the awareness group was instructed to pay attention to environmental and body cues as was typically the case in most beginner instructional programs. The control group was given information in terms of what to do but not how to perform or use any strategy. In line with these orientations, the nonawareness group would be predicted to perform better than the awareness group, and both of those groups would perform better than subjects in the control group.

The subjects in the awareness group were expected to show greater proficiency than the control subjects. This should be due to the belief that directing individuals at the early stage of learning to pay attention to specific cues while performing should lead to advantageous results. The awareness subjects were given specific directions about how to approach performance. Thus, the specific directions for awareness should lead to better outcomes as compared to the control condition. Davies (1945) and Parker and Fleishman (1961) found that subjects who were directed how to perform tasks achieved better than subjects who did not receive any formal instructions.

3. The Five-Step Approach group should have contributed to higher skill attainment than the awareness, the nonawareness, and the control conditions. It has generally been found that the Five-Step Approach has enhanced performance (Singer & Suwanthada, 1986) as compared to control conditions. It has facilitated achievement in artificial laboratory tasks (Singer, Flora, & Abourezk, 1989b) as well as sport type tasks (Singer, DeFrancesco, & Randall, 1989), self-paced in motion.

Although this technique contained two steps of preparation (readying and imaging), during the fourth step (executing) the subjects were instructed "...not to think of anything about the act itself or the possible outcomes" (Singer, 1988, p.56). In addition, focusing attention intensely on a specific cue (third step) and evaluating (fifth step) were also two processes that have been used extensively by the highly skilled.

In comparison with the awareness and the nonawareness strategies, the Five-Step Approach apparently contained essential as well as additional guidelines. Although the strategy can be used effectively by advanced learners, perhaps beginners can also benefit from using the technique. However, this depends upon the steps to be emphasized. For example, skilled performers may stress the third (focusing) and fifth (evaluating) steps, while novices may stress the first (readying) and second (imaging) steps. Thus, if both beginners and experts apply the complete technique, subjects in the Five-Step Approach group should perform better than subjects in the awareness and nonawareness groups. In other words, achievement can be advanced in any stage of learning and performance (early or late) by applying the Five-Step Approach.

4. Although two different samples of subjects were tested in the two experiments proposed, it was hypothesized that the skill realized in both the ball-throwing task and the key-pressing task would be facilitated through the use of the awareness, the nonawareness, and the Five-Step Approach strategies. Performance differences for each task

were expected in the same direction as stated in the previously stated hypotheses. Singer, DeFrancesco, and Randall (1989) found improved performance in two motor tasks when the same subjects used the Five-Step Approach.

Kurtz and Borkowski (1984), Singer (1988), and Singer and Cauraugh (1985) have reasoned that learners can and should develop the ability to transfer knowledge from one learning situation to another related situation. If learners are able to acquire task-pertinent strategies and implement them while learning one activity, then, when a new activity is introduced, the principles of the same strategy should also apply. Better learners would modify meaningful strategies to the new demands of the situation, and consequently benefit from the prior experiences.

These ideas were pertinent to this investigation, although the two tasks (ball-throwing and key-pressing) in the study proposed here were performed by two different samples of subjects in each experiment. It was believed that the strategy orientations that were given, not only to the subjects in the Five-Step Approach group, but also to the awareness and the nonawareness subjects, could be appropriately transferred across related tasks. The same results were expected in each experiment, even though the tasks were quite different. The main similarity was that they were both self-paced in nature.

If two motor tasks share the same conditions (Anderson, 1987), such as situational context and response demands, then a task-related strategy may be applied with minor adjustments. On the other hand, if learners are asked to perform two different tasks, which do not share the same conditions, then major adjustments or modifications in the strategy will be required from the first condition to the second one. In this study, the ball-throwing and key-pressing tasks were self-paced and have these characteristics in common. However, these two tasks were different, and although the strategies imposed on the groups in each experiment were the same, they would need to be applied accordingly. In this study, the attempt was made to determine the generality of each strategy across the different tasks studied in each experiment.

5. While performing two activities simultaneously (the ball-throwing task and a verbal task, or the key-pressing task and a verbal task), subjects using learning strategies (awareness, nonawareness, and Five-Step Approach) would demonstrate a higher skill level in the primary task than subjects in the control group. Researchers (Cremer & Ashton, 1981; Navon & Gopher, 1979; Trumbo, Noble, & Swink, 1967) have reported that the presence of a secondary task typically results in a performance decrement in the primary task (because the demands of two tasks compete for the use of a person's central limited attentional capacity). However, an assumption was made that if a particular

learning strategy assisted a subject to attain a state of automaticity in performing the primary task, then simultaneously performing another task would not negatively influence the performance of the primary task. The primary task would not require any conscious attention.

Additionally, among the four learning situations, the nonawareness and the Five-Step conditions would lead to better outcomes than the awareness condition. If, as expected, they contributed to higher levels of competency in the primary task (ball-throwing or key-pressing), then performance would remain at a higher level when a secondary task (verbal report) was introduced.

Definitions of Terms

To understand the terminology in the present study, the following terms were defined.

Absolute Constant Error (ACE) refers to the absolute value of average signed scores (Safrit, Spray, & Diewert, 1980).

Automaticity (Automatization) in Skilled Performance is implied when a person performs a task without attentional control or mandatory focus of attention. The task is executed quickly, accurately, and effortlessly (Logan, 1988a; Norman & Shallice, 1986).

Awareness Strategy is a learning approach associated with paying attention to kinesthetic cues, the feeling of the movements, thinking about the act itself, and attempting to be aware of the details of the situation and the performance (Adams, 1968; Clark & Norch, 1986).

Dual-Task Paradigm is a methodology in cognitive psychology that has been used to describe the mechanisms, processes, and limitations of human attention and information processing. The basic notion is that when two tasks are simultaneously performed, they share the same limited human capacity system (Trumbo, 1977).

Five-Step Approach is a learning strategy that is sequentially composed of the following steps: readying, imaging, focusing, executing, and evaluating. This strategy is relatively content-independent and designed to improve learning and performance in all motor tasks classified as self-paced (Singer, 1982, 1988).

Learning Strategy is a form of guidance for individuals about how to learn and perform, not only what to learn and what to perform (Good & Brophy, 1990; Singer, 1988).

Movement Time (MT) refers to the interval from the initiation of a movement to its termination.

Nonawareness Strategy is a learning approach that focuses on learning skills as if in a state of automaticity, in which movements and actions are preplanned, flow, and "things just seem to happen." Performers trust themselves, relax, and let the movements flow without any conscious attention or thinking about the act while executing (Loehr, 1982; Schneider & Fisk, 1983).

Reaction Time (RT) refer to the interval from the presentation of a stimulus to the initiation of a response.

Response Time (TT) refers to the interval from the presentation of a stimulus to the completion of a movement; the sum of reaction time and movement time.

Self-Paced Skill is an act performed in a relatively stable and predictable environment, with no time constraints as to initiating the movement (Singer, 1980a).

Variable Error (VE) refers to the standard deviation of a set of responses about the subject's own average score; a measure of response consistency (Schmidt, 1988).

Assumptions

For the purpose of this investigation, the following assumptions were made:

1. A nondominant hand ball-throwing task, and a dominant hand key-pressing task were relatively novel to subjects.

2. Although college students (subjects who participated in these studies) possessed an intelligence level greater than the average population of people, it was assumed that the cognitive capacities required for processing the learning information associated with the tasks used in this study would not be exceptional. Therefore, it was expected that the subjects would acquire the learning strategies to a reasonable degree under the conditions of the study in the same manner that non-college

students would. Thus, the research findings could be generalized to people in general.

3. The secondary task presented in the dual-task paradigm was relatively easy to perform but sufficiently challenging to potentially result in a slight interference with the primary task.

4. In the dual-task situation, it was assumed that subjects would be able to apply the particular strategy (with very few adjustments) while the second task was introduced, thereby enabling them to maintain reasonable performance in the primary task while performing at a sufficient level in the secondary task.

5. The dependent variables that were used in these studies (such as ACE, VE, MT, and RT) were typical and appropriate measurements in motor learning, and for all purposes of this investigation. It was assumed that these variables would yield sufficient quantitative information about (a) the actual movement that the subjects made and (b) how well the movement achieved goals that were inherent in the task (e.g., whether or not the ball hit the center of the target).

Significance of the Study

The simplified human performance model proposed by Welford (1968) has been readily accepted by motor learning scholars (cf. Marteniuk, 1976; Singer, 1980a). The model provides an understanding of the information processing activities that are included in the performance of motor skills. That is, it contains three mechanisms (perceptual, decision, and effector), and describes how a person processes information in an attempt to acquire motor skills.

Emphasized are the transitions that individuals undergo as they advance from one stage of learning to another during the learning process. However, only guidelines about what to do in terms of requirements and conditions to be met while acquiring a skill are given at each learning phase. Such is the case with most models of motor performance proposed in the literature. Unfortunately, not much guidance has been provided for the need to teach learners how "...to think, to evaluate, to develop alternative responses, and to problem solve" (Singer, 1980b, p. 591). Appropriate strategies to deal with immediate task-learning situations as well as subsequent situations need to be acquired, and should be developed according to one's knowledge about the processes and mechanisms involved in learning and performing skills.

Among motor learning researchers, Singer and his colleagues (cf. Singer, 1988; Singer & Cauraugh, 1985; Singer, Flora, & Abourezk, 1989a; Singer & Suwanthada, 1986) have primarily shown an interest in this area. As was indicated earlier in this chapter, enhanced performance has been observed in various studies when subjects were instructed in the use of the Five-Step Learning Strategy.

The Five-Step Approach can apparently assist learners in (a) facilitating learning in a specific self-paced situations and in (b) preparing them to deal with future similar but related learning situations.

Hence, in line with these studies, the intention in this investigation was to further investigate the effectiveness of various learning strategies across different motor tasks. More specifically, different, potentially effective learning strategies were compared as to their relative influence on rate of learning and ultimate achievement.

In this matter, it is interesting to compare the Five-Step Approach that has already been established as a useful technique in enhancing self-paced motor tasks with awareness and nonawareness strategies which are new approaches to learning and performance, but somewhat related to the Five-Step Approach. It is believed that the Five-Step Approach is not only more comprehensive but also more effective than the awareness and nonawareness strategies because it contains both awareness and nonawareness elements; therefore, individuals using the strategy should know what to do before as well as during execution. However, this may be a disadvantage for instructors and learners. First, more time is needed to teach appropriately the strategy. Second, it may not be possible to use all the five steps during a real-life situation (e.g., a game). By comparing the three learning strategies, an evaluation of the advantages and disadvantages of each strategy to particular learning environments in which self-paced tasks are acquired can be made.

Data from this study will be helpful in (a) determining the performance effects of different learning strategies that can assist learners to perform different motor tasks; (b) examining the ability of novices to approach performance as skilled performers do; and (c) determining the effectiveness of these learning strategies in maintaining an advanced phase of learning under dual-task performance conditions.

Instructors as well as learners should derive potential benefits from this study. On one hand, instructors should be aware of task demands and the learning characteristics of typical learners at different stages of achievement. This would enable them to suggest particular strategies that might be helpful during the practicing of a skill. On the other hand, learners should understand that after a program of formal instruction is completed they will not have any more guidance. Future involvement in the activity and possibilities of success will be determined by personal abilities to use task and self-analyze skills; in other words, to apply strategies as appropriate. Future situations will probably vary from the training program, thereby requiring adaptive strategies. In addition, if a degree of performance excellence is desired, as the form of being able to execute with proficiency and as if in a state of automaticity, these strategies that contribute to such an outcome need to be acquired and applied.

Research on the effectiveness of learning strategies associated with advanced phases of success has been rarely undertaken so far. Annett (1985), for example, has stated that more research must be conducted in motor learning on prolonged practice in complex tasks to understand advanced performance or automatic processes. Adams (1987) agreed with this notion and postulated that "... a concern with behavioral mechanisms and how they change with practice could accelerate interest in the mechanisms and theory of action..." (p. 66). Specifically, more research in motor learning is needed that focuses on (1) how learners achieve skilled performance, and even attain a state of automaticity and (2) what the mechanisms are involved in this process. Learning strategies as they influence cognitive processes are heavily involved in understanding these two areas of interest.

For these reasons, further investigations in motor learning should be focused on the usefulness of learning strategies in early as well-advanced stages of skill acquisition. It may be discovered that by applying a particular learning approach (for example, the nonawareness strategy) at beginning as well as advanced stages of practice it is possible to attain a high level of proficiency and to maintain it under increasingly demanding situations. In addition, the time needed for attaining reasonable skill or even a state of automaticity may be reduced. More time could be spent on improving other learning capabilities, such as error detection and correction (Rabbitt & Banerji, 1989; Senders & Moray, 1991).

In conclusion, three important contributions are expected to result from the present investigation. First of all, the novice-expert relationship is reexamined in terms of learning strategies used by experts that might be used successfully by beginners in the early stage of practice. Second, the relative effectiveness of different learning strategies is determined as to contributing to a high level of proficiency. Third, comparisons of strategy usefulness are also made in regard to performing two tasks at the same time. In this matter, the influence of the three learning strategies on achievement in the primary task when a secondary task was introduced would be studied to ascertain how automated the primary task became as associated with a particular strategy. Hopefully, this knowledge would further advance the understanding of the learning of self-paced motor tasks as well as later stages in the skilled performance process. Thus, instructors may design more appropriate learning situations and performance conditions.

CHAPTER 2

REVIEW OF LITERATURE

To provide a systematic comprehensive overview of the research areas of interest, the related literature is organized in the following manner. In the first section, perspectives on learning strategies will be discussed. The second section will include an overview of the Five-Step Approach, a global strategy that has been developed for the learning and performing of self-paced motor skills. In the third section, a discussion on self or body-awareness approaches to learning is presented, and the role and mechanisms of proprioceptive feedback are reviewed.

Included in the fourth section is an overview of research on such themes as performing motor skills without awareness, concepts related to automaticity, practice considerations, expert-novice differences, and characteristics of expertise in sport. Additionally, dual-task paradigms will be reviewed as they relate to performance, attention, and automaticity. Finally, a comparison of the effectiveness of awareness versus nonawareness approaches to achievement is offered in the sixth and last section.

Learning Strategies

Interpretations

Although the term, learning strategy, has been defined in several ways, it seems that there are many similar practical implications among these interpretations. Singer (1988) has defined a learning strategy as a form of guidance for learners to acquire skill, as well as an approach that should be helpful for individuals in selecting performance strategies and building or repairing them. According to Logan and Zbrodoff (1982), a strategy is an optimal organization of cognitive processes designed to achieve a goal for a task. Additionally, Good and Brophy (1990) have stated that strategies are general principles of problem-solving and "learning to learn" skills.

The improvement of learning ability necessitates development not only of specific learning skills but also "an executive control mechanism that automatically accesses and combines learning skills whenever they are needed" (Derry & Murphy, 1986, p. 1). For Gagné (1985), a learning strategy is a form of problem-solving ability, and for Bruner, Goodnow, and Austin (1956), the term describes an intellectual capability that enables individuals to control the way in which they think in problem-solving situations.

For some scholars (e.g., Flavell, 1979) the term learning strategy contains concepts such as metacognition, metacognitive awareness, and metamemory, which emphasize higher-order internal processes associated with using a strategy. Metacognition, according to Singer (1988), is defined as one's knowledge about one's cognitive processes and her or his ability to direct them. Good and Brophy (1990) have added that this knowledge is also about how cognitive processes function. Metacognitive awareness has been defined as a person's conscious monitoring of his or her own cognitive strategies during the process of applying them (Kail & Hagen, 1982), and metamemory as knowledge about how memory works and how to memorize effectively (Flavell & Wellman, 1977).

Considering these interpretations, a learning strategy is the overall plan one formulates for accomplishing particular achievement goals with a learning task, and the knowledge about the usefulness of this plan. In addition, strategies refer to the behaviors and thoughts that a learner activates during learning in an attempt to influence information processing processes and, in turn, level of achievement in an activity.

Characteristics and Effectiveness of Learning Strategies

Norman (1980) has proposed that "we need to develop the general principles of how to learn, how to remember, and how to solve problems" (p. 97). Additionally, Weinstein and Mayer (1986) have stated that "good teaching" includes teaching students how to learn, how to remember, how to think, and how to motivate themselves. It seems that results of studies in educational psychology and motor learning may provide appropriate techniques for instructors (and learners) to improve these capabilities (e.g., Kurtz & Borkowsky, 1984; Singer, DeFrancesco, & Randall, 1989).

For the learning of academic subject matter, Weinstein and Mayer (1986) have identified five general types of learning strategies: (1) rehearsal (being involved actively repeating by either saying or writing the material or focusing attention on key parts of it); (2) elaboration (being involved in making connections between the new material and more familiar material); (3) organizational (being involved in imposing structure on the material by subdividing it into parts or clusters); (4) comprehension-monitoring (being involved in remaining aware of what one is trying to accomplish during a learning task, keeping track of the strategies one uses and the degree of success achieved with them, and adjusting behavior accordingly); and (5) affective (being involved in eliminating undesirable affect and getting ready to learn).

For each one of the these strategies, there is evidence to show their effectiveness during learning and performance. For example, Richards and August (1975) found that students who were asked to underline sentences in a passage (rehearsal strategy) were able to substantially recall more information than students who simple read the passage without underlining. Reese (1977) has found that an imposed imagery (elaboration strategy) tends to improve paired-associate learning performance for kindergartners and first grade. Also, Moely, Olson, Howles, and Flavell (1989) have shown that children who were taught how to apply the organizing strategy to list learning were able to enhance their recall performance.

Considering the educational psychology research, two primary characteristics of an effective strategy have been described in the literature:

1. Two classes of strategies have been categorized: primary and supportive. According to Dansereau (1978), a primary strategy assists learners to acquire a specific task (for example, task-specific encoding and retrieval of information), while a supportive strategy helps learners to improve the operation of the primary strategy (for example, a self-management technique). Furthermore, a supportive strategy may improve learners' attitudes toward the learning and performance of the task, and help learners to cope with external or internal distractions (Singer, 1982).

2. The degree of specificity or generality potential of strategies has been characterized. A strategy may facilitate learning and performance of (1) a specific task (such as how to write the English letters in order) or (2) a category of related activities (such as how to memorize key sentences in a paragraph). According to Dansereau (1985), a specific strategy can be termed as a content-dependent

strategy, and a more general strategy can be considered as a content-independent strategy. In the motor domain, Singer and Cauraugh (1985) recommended that learners should be taught generalizable strategies more frequently in order to apply them across different tasks in subsequent learning situations.

Not only in educational psychology are there situations in which learners have been taught task-relevant learning strategies (specific and general) which have resulted in better learning and performance. In addition, the usefulness of learning strategies has been determined in motor learning research.

For example, when studying the effect of a learning strategy (the Five-Step Approach) on skill attainment in self-paced motor tasks, Singer and his colleagues (Singer, 1988; Singer, DeFrancesco, & Randall, 1989; Singer & Suwanthada, 1986) found that subjects who were taught the strategy achieved at a higher level than those who did not receive it. Of special interest are two studies by Singer and Suwanthada (1986) and Singer, Defrancesco, and Randall (1989). In the first one (Singer & Suwanthada, 1986), the value of the Five-Step Approach as a general task-referenced strategy was investigated. Subjects were asked to perform three different tasks: (1) a specific task (underhand dart-throwing), (2) a very related task (jart-throwing), and (3) a less related task (soccer foul-shooting). The commonality among the three tasks was that they were self-paced. Two prominent findings emerged from this investigation. First, all subjects in the strategy groups (the strategy was introduced under different conditions to different groups of subjects) performed better than the control subjects across all three learning tasks. Second, subjects who were taught the strategy as content-independent (without reference to any one specific task) achieved better in the transfer tasks than subjects who were provided with directions that introduced the strategy as content-dependent (with specific reference to only the primary task).

In addition, when the experimenter reminded the subjects to use the particular strategy, performance was facilitated. Reminders are apparently necessary to focus learners attention. In this case, subjects were aware of strategy usage in different contexts and were able to transfer the five sequential strategies (readying, imaging, focusing attention, executing, and evaluating) efficiently across three tasks.

In the second study (Singer, DeFrancesco, & Randall, 1989), further investigation on the transferability of the Five-Step Approach was conducted. More specifically, the effectiveness of the strategy on achievement in laboratory and simulated self-paced sport tasks was investigated. Subjects were instructed to perform (1) either a laboratory task (a novel but complex motor task requiring speed and accuracy in movement) or an applied sport task (a modified table-tennis service) as a primary task and (2) a transfer task (seated underhand dart-throwing). Subjects who were instructed to use the strategy accomplished more than subjects who did not use it in the primary task as well as in the transfer task. It was concluded that the Five-Step Strategy enhanced achievement in an artificial laboratory task as well as a sport-type task.

In line with these results, it is important to note two things. First, learners can benefit from learning strategy usage in different learning situations when they are instructed properly. If this knowledge can be applied across different motor tasks, then learners would be as an advantage as they attempt to acquire new but related skills. In other words, efficiency in the early stages of learning would be demonstrated. Moreover, with experience and practice with the task, performance should be enhanced even more.

Second, individuals in general will probably need to be reminded to initiate relevant strategy usage throughout the early stage of learning. It is easy to forget when confronting the performance demands in a situation. If one of the purposes of learning strategy usage is to direct learner behaviors and thoughts during learning, instructors may have to remind learners to remember what to do. However, it seems that after some practice, learners should be able to initiate appropriate strategies spontaneously. Thus, in the current investigation, this recommendation will be applied and reminders will be given to subjects every few trials in order to assist them in using the particular strategy consistently.

The Point of Introduction

One of the important issues in the learning process is when to introduce a learning strategy to learners. Two options are available. First, instructors may consider introducing the strategy before practice begins. In this case, learners are instructed in the strategy before they gain any degree of experience with the learning activity. Consequently, the task and the strategy would be considered as an integral aspect of the beginning instructional program. Second, instructors may introduce the strategy during the learning/training process, after some degree of task practice has occurred. In this case, learners have received information about 'what to do', and then begin the training session. After some experience with the task, they are introduced to the strategy and instructed how to apply it during subsequent task practice.

Research in educational psychology and motor learning provides a clear suggestion how educators should address this issue. In spite of results from one study that suggested the introduction of the strategy after some degree of experience with the task (Singer & Mariakis, 1986), it has been recommended that the strategy be experienced before practice with the learning task begins (e.g., Paris, Newman, & McVey, 1982; Singer, Flora, & Abourezk, 1989b).

Singer and Mariakis (1986) found that introducing the strategy after some degree of practice with a task resulted in best performance. In this study, subjects who had already performed 20% of the total trials to be administered for a learning task were taught the strategy (the Five-Step Approach) and performed better than subjects who were introduced to the strategy before actual practice began. In addition, the 20% subjects achieved better than subjects who were introduced to the strategy after completion of 50% of the total trials. According to Singer and Mariakis, prior experience (however, not extensive practice) with the task was helpful for beginners applying the strategy as they could use task-pertinent experience to their advantage when they attempted to use the strategy.

However, these results are not reflective of the major findings that have emerged from research in this area. Singer, Flora, and Abourezk (1989b) observed that subjects in the group that was taught the strategy (the Five-Step Approach) before having any practice with the task performed better (in terms of movement time) than the subjects in the other groups who were introduced to the strategy at different stages of learning. The strategy was introduced prior to practice or after 25% or 50% of the trials were performed. These results seemed to indicate that when learners had some practice experience with the task, they had already established their own strategies. Then, when introduced to the task learning strategy, interference with their own strategies may have occurred.

In line with the findings of Singer, Flora, and Abourezk (1989b), the three learning strategies to be scheduled in the present investigation will be introduced to the subjects prior to actual practice with the task. Although the two tasks (ball-throwing and key-pressing) that will be undertaken in this project are considered to be novel, subjects may have some experience with other forms of either task. For example, virtually every subject will have had ball-throwing experience in various sports, and would be familiar with throwing activities. In addition, subjects may have typed term papers on a computer or with a typewriter, and thus would have experienced key-pressing. In this study, in order to minimize the use of strategies developed previously in learning experiences, subjects will be directed how to use the particular strategy of interest before receiving any official practice with the task.

Returning to the Five-Step Approach, as has been pointed out on a number of occasions in this paper, the strategy has been the subject of study in a number motor learning investigations. However, until now, the effectiveness of this strategy has not been compared with other strategies. In this investigation, one of the groups will be instructed to use this technique. Hence, an overview of the Five-Step Approach is provided in the next section.

The Five-Step Learning Strategy

Singer's Five-Step Approach is a global strategy which contains five sequential steps: Readying → Imaging → Focusing → Executing → Evaluating. It has been proposed as a facilitator in learning as well as performing of all types of self-paced skills (Singer, 1986, 1988). Confirmation has come with a variety of tasks (Singer, 1988; Singer, DeFrancesco, & Randall, 1989; Singer, Flora, & Abourezk, 1989a, 1989b; Singer & Mariakis, 1986; Singer & Suwanthada, 1986).

In most studies, subjects have been given strategy training sessions before practice and were asked to apply it when learning a primary task and possibly subsequent related tasks. In addition to the ability to enhance the acquisition of a primary motor task, apparently the strategy can be successfully applied to a transfer task (Singer, DeFrancesco, & Randall, 1989; Singer & Suwanthada, 1986). For example, in the first study, after performing a key-pressing task (primary task), subjects were asked to perform a dart-throwing task (transfer task). Performance was enhanced in the primary task as well as in the transfer task through the use of the strategy.

It seems that the influence of the strategy across different self-paced motor tasks is due to it containing five substrategies which intuitively seem to be beneficial for achievement. In addition, each substrategy has been subjected to a fair amount of scientific scrutiny. For example, extensive research has been undertaken on (1) imagery as an intervention technique in clinical psychology (Cuthbert, Kristeller, Simons, Hodes, & Lang, 1981) as well as a performance enhancement technique in sport (Straub, 1989), (2) attention as a theoretical theme (Shiffrin, 1989), (3) the focus of attention as a useful and practical technique to block internal and external distractors before and during performance (Singer, Cauraugh, Murphey, Chen, & Lidor, 1991), and (4) performance excellence associated with a state of automaticity (performing without conscious awareness), (Logan, 1988a).

Singer (1984, 1986, 1988) and Singer and Cauruagh (1985) have described in detail each of the steps of the Five-Step Approach. The procedures of each step are outlined in Table 1 (DeFrancesco, 1989), and an overview of it follows.

Table 1

The Singer Five-Step Learning Strategy

Readying
* get comfortable physically
* attain an optimal mental-emotional state
* attempt to do things in preparation that are associated with previous best performance
* try to be consistent in attaining the preparatory state for the act

Imaging
* mentally picture yourself performing the act briefly as to how it should be done, from the result of the act to the initiation of the movement
* think positive and feel confident
* feel the movement

Focusing
* concentrate intensely on one relevant feature of the situation, such as the seams of the tennis ball to be hit
* think only of this cue, which will block out all other thoughts

Executing
* do it
* do not think of anything about the act itself or the possible outcome

Evaluating
* if time permits, use available feedback information to learn from
* assess the performance outcome and the effectiveness of each step in the routine
* adjust any procedure next time, if necessary

Step 1: Readying

When performing any motor skill, the learner must be psychologically, mentally, and physically ready to execute at his or her best. For example, the person should ideally know how to control and direct emotions and motivations in order to achieve an optimal arousal condition for the task to be learned/performed (Landers, 1982).

In fact, research on the relationship between arousal and performance has indicated that performance is better when arousal level is appropriate for the task (Gould, Horn, & Spreeman, 1983; Powell & Verner, 1982). A person with low arousal is typically unmotivated while a person with high arousal is overwhelmed and disorganized. Under these conditions, performance will be hampered.

It has been proposed by Bandura (1990) that self-beliefs of efficacy influence how people feel, think, and act. In other words, the actual performance will be predicted by the individual's belief in personal competence. Thus, it is recommended that the performer convinces him/herself that he/she can successfully execute the task.

Additionally, Gould (1986) and Lock and Lathman (1985) have reported that individuals may set learning and performance goals. The goals must be specific, difficult but realistic, and positive. Thus, by setting appropriate expectations, learners may (a) be ready mentally to perform the activity (knowing what they can do at their best and what they want to do), (b) be motivated to achieve better, and (c) increase the probability of success.

In regard to this research, Singer (1982, 1986) has emphasized four points to consider in the psychological and cognitive preparatory state of the learner:

1. Previous experience, familiarity, and skill level in the present activity.

2. Previous best performance in the same or similar events.

3. Cognitive style (personal approaches to addressing and solving problems).

4. Attitude and feeling toward and in the situation.

Hence, in this stage, learners should try to attain a constructive preparatory routine, and to develop consistency in its use. In addition, positive thinking about the coming event, the act, or the outcome can benefit performance.

Step 2: Imaging

Imaging has been defined as a process in which the performer visualizes him/herself performing the event to the best of ability (Weinberg, 1984). In addition, to enhance imaging, included may be a kinesthetic awareness of the movement (Singer, 1982) or even a form of self-talk (Singer & Cauraugh, 1984). Ryan and Simons (1982) have proposed that the more clearly and vividly a learner can form the mental presentation of the event, the better the act will be executed.

Research in sport psychology and motor learning has shown that imagery practice can be effective in enhancing achievement (Epstein, 1980; Mahoney, 1974; Meichenbaum, 1976; Weinberg, Seabourne, & Jackson, 1981). In these studies, learners who were instructed how to use appropriately imagery techniques seemed to benefit from it while acquiring a new skill.

There are different ways to imagine, however. For example, a distinction has been made between the terms "internal" and "external" imagery. Internal imagery involves seeing or feeling something from the performer's own point of view. In other words, the learner images him/herself perform the act. On the other hand, external imagery occurs when a performer views him/herself from the point of view of an external observer. Both internal and external imagery techniques can assist learners (Weinberg, 1984), however, internal imagery techniques may be more desirable because proprioceptive mechanisms can be involved in the process, possibly leading to strengthening of the visual presentation (Epstein, 1980).

Pursuing this line of reasoning, internal imagery is recommended for the Five-Step Approach (Singer, 1988). Learners should not only mentally picture themselves doing the act at their very best, but also try to feel the movement being performed.

Step 3: Focusing Attention

According to Shiffrin (1989), the term attention has been used to refer to all aspects of human cognition that people can controlled and having to do with limited resources or capacity. Additionally, Singer, Cauraugh, Murphey, Chen, and Lidor (1991) have pointed out that attentional processes are associated with many stages in information processing. For instance, focus on the most relevant cue of those available at a particular point of time is important in order to execute a task successfully. Of course it may be necessary to divide attention between cues, depending on the performance concept. Irrelevant sources of information need to be ignored and non-attended.

Singer, Cauraugh, Tennant, Murphey, Chen, and Lidor (1991) have reviewed concepts and research on distractors and attentional processes in relation to the performance of motor skills. They have postulated that there are no clear-cut conclusions in regard to distractor effects on performance although it is generally believed that distractors can potentially disrupt performance unless appropriate attentional focusing techniques are used. Suprizingly, only a few studies have been undertaken on attentional programs and distractors.

In this context, applied sport psychologists, such as Gallwey (1981), Nideffer (1981), and Orlick (1990) have developed training programs for assisting athletes to improve their ability to direct their attention appropriately during performance. Although more research is needed to determine the effectiveness of such programs, it is reported that learners seem to benefit from such experience. For example, in Gallwey's program, golfers are asked to focus their attention on a very specific cue (such as listening to the sound of the ball impacting the golf club) as well as to relax and "let the movement go" (Gallwey, 1981). By this procedure, beginners and skilled performers may (1) reduce their information processing activity, (2) block any potential distractors (internal or external), and (3) perform the task without conscious attention and as if in a state of automaticity.

While performing a self-paced task, individuals have the time to select the appropriate cue and to focus their attention correctly. When the same activity is repeated under almost the same conditions, he/she should be able to develop an optimal state of concentration. This by itself may lead to a reduced negative effect of any potential distractors, thereby, resulting in better performance.

For the Five-Step Approach, Singer (1988) has provided the following guidelines during the performing of an act:

1. Concentrate intensely on one relevant feature.
2. Think only of this specific cue.
3. The intent is to block out any other internal or external thoughts.

Step 4: Executing

In this step, the learner should perform without thinking of the act or the outcome of act (Singer, 1988). When the optimal focus of attention has been attained, then the self-paced task (which is self-initiated) should be executed. Singer (1988) has pointed out that "the self-mechanism seems to say, 'do it'" (p. 58). To execute movements in this way requires two conditions: (1) an appropriate motor program must be selected (Rosenbaum, 1985) and (2) the act needs to be reasonably well-learned through sufficient experiences (Schneider, 1982, 1985).

These two conditions are related to each other. The term, motor program, has been interpreted in various ways. Originally, motor program has been defined as a set of muscle commands that allows the entire sequence to be carried out uninfluenced by peripheral feedback (Keele, 1968). Schmidt (1991) provided a similar but more general definition by stating that a motor program contains a prestructured set of movement commands that defines and shapes the movements. Other contemporary definitions have extended the implications of the term even more. For example, Rosenbaum (1991) has defined it as a functional state that allows particular movements, or classes of movements, to occur.

Keele's (1968) concept of motor program may be the most appropriate one to explain the state of performance undertaken in the fourth step of the strategy. An individual uses a motor program as a structured plan, based on previous experience, to execute the task as automatically as possible without thinking of it. This program is selected with regard to two factors: (1) the goal of the activity and (2) the particular situational requirement. Rosenbaum (1985, Experiments 3, 4, and 5) seems to take into account these two considerations, while proposing a model (the hierarchical editor model) in which an explanation is given on how motor programs are selected. According to Rosenbaum, a specific selector picks up the appropriate motor program and cancels the irrelevant ones, and only then the movement can be executed. If performers execute the same movement over and over, the time necessitated to choose the right motor program becomes shorter.

In this context, a well-trained performer is able to react rapidly to a presented stimulus (in terms of saving time when choosing an appropriate motor program), and to automatically perform the task as a result of extensive practice. If a self-paced task is practiced extensively and under the same conditions (for example, serving a tennis ball to the same spot with the same intensity), then the task will be performed automatically and without conscious attention (Schneider, 1982, 1985). Also the process of selecting an appropriate motor program (for example, the same parameters of movement: force, direction, and velocity) will be faster (Rosenbaum, 1985). In these conditions, automatization of the skill will result in reducing any awareness of act during performance, and consequently, less attention to the specific action is required (Schneider, 1985).

For the investigation proposed here, this step of the strategy is salient. The fourth step considers the actual behaviors and thoughts of the learner while performing the motor task. During the first three steps of the strategy, learners are asked to prepare themselves to perform the task. They are instructed that by following these preparation stages (readying, imaging, and focusing attention) performance will be facilitated. However, in the fourth step, learners are directed to execute the movement without thinking of anything. They are asked to perform the task without being aware of what they are doing, and "just do it" (Singer, 1988). This state of the strategy seems to represent how skilled performers performing at their best approach a situation. Thus, beginners are guided to approach performance as experts do.

Step 5: Evaluating

If time permits between attempts at the task, the learner should analyze (a) the quality of the performance and (b) the effectiveness of each substrategy (Singer, 1988). However, if time does not permit, this step should be omitted. Time is typically available during practice or a training session but may not be under real-performance conditions.

Learners can use their own movement-generated feedback to evaluate their performance. In most self-paced tasks, performers are able to see the outcome of their performance. For example, basketball players can see if the foul-shot was successfully made during the game. If they missed the target, then they are able to (1) use visual information to evaluate their last trial, (2) analyze what were the causes for this poor performance, (3) suggest to themselves a better way to shoot the ball, and (4) perform better in the next trial. In this case, self-feedback can be used by the person without any need of feedback from an external source, such as a coach.

However, inadequate execution may be due to factors other than poor mechanics. Besides feedback information to evaluate performance outcome, the ability to correctly evaluate how well the processes associated with the previous four steps of the strategy were activated is also important, and very infrequently considered. If there is sufficient time, as in practice, the contribution of each of the steps to the quality of the performance of an act can be quickly assessed. It is impossible for instructors to evaluate the steps or the learner's cognitive and psychological state. The extent that the learner images ideally immediately prior to an act, for example, can only be determined by the learner. A verbal report can be given by the individual to the instructor after the performance is completed. The better that one can analyze and evaluate the contribution of each substrategy to the actual performance, the more appropriate corrective steps can be taken. For example, if a lack of focused attention is a problem, emphasis should be placed on improving this phase in the overall sequence of events.

Overview of Learning Strategies

Research in educational psychology and motor learning has indicated that achievement in cognitive and motor tasks can be influenced positively through the use of task-relevant strategies. Learning strategies generally refer to the behaviors and thoughts that a learner engages in during purposeful learning. Helping learners (1) to learn, (2) to learn how to learn, (3) to acquire self-evaluation and self-management skills, (4) to solve problems, (5) to apply general principles to specific situations, and (6) to transfer previous knowledge to new learning situations should be major goals in educational programs (Garner, 1990; Peverly, 1991; Siegler, 1988; Weinstein & Mayer, 1986). Not only can learning strategies help students to achieve better in a specific activity, under the right conditions they can provide organizational and motivational tools to achieve more effectively in a number of relative tasks (Singer, 1988).

The Five-Step Approach is an example of a global learning strategy for achieving in self-paced motor skills. However, research is needed to determine other potential meaningful strategies as compared with the Five-Step Approach. There may be better alternatives. In most studies, which are reported in this section, subjects were instructed to use only the Five-Step Approach as a learning strategy. They have been compared to control groups or other Five-Step Strategy groups for which certain conditions have been manipulated. Thus, it would be worthwhile to study the degree of skill attainment as associated with different types of strategies that appear to have merit.

For example, if it is important to direct learners' thoughts during performance, then on what cues should they pay attention? Should they be trained to think about specific things or should they be trained not to reflect any thoughts to what they are doing? On the one hand, beginners are typically directed by instructors to pay attention to what they are doing, and to be aware of the way in which they execute movements. On the other hand, if learners try to imitate skilled performers, it seems that they should not pay attention to what they are doing, and to just let the movements flow without thinking about them.

Hence, it is of considerable interest to determine if beginners benefit any differently from these opposing learning/performance strategies, and they will be investigated in this study and compared with the Five-Step Strategy. Beginners may accomplish better by approaching the task during execution as skilled individuals do. By performing the act as if in a state of automaticity and without allocating any attentional resources to it, learners may perform the activity accurately and effortlessly (Schneider & Fisk, 1983). These two approaches to instruction and learning, awareness versus nonawareness states, will be discussed next.

The Awareness Approach to Learning and Performance

Although in many learning situations skills are performed without conscious attention and thoughts, it is apparent that beginners frequently think about the activity they are to learn and do pay attention to what they are doing. Even more highly skilled individuals frequently attempt to think about what they are doing. Others, who would like to block an awareness of thoughts irrelevant to good performance, do not know how to.

Beginners are usually told by instructors to be aware of what they are doing, and to use self-cues to control their movements. Adams (1968), for example, has postulated that sensory feedback from responses can be used to perform variety of motor tasks (specifically, linear and slow movements). Additionally, Keele (1968) has stated that there are three possible ways in which movements can be controlled (1) visual feedback, (2) kinesthetic feedback, and (3) motor programs. According to Keele, visual information is the most important source in human movement control. If the learner is able to see what he/she is doing, and the movement is made slowly enough, then errors can be easily corrected. When vision is not available, then kinesthetic cues may be used. In this case, by feeling the movement and paying attention to the way which the act is performed, control may be achieved. However, when the movement is executed, for example, in a ballistic manner, a motor program is needed to perform the task. The motor program is based on repeated previous experiences with the same task and is planned in advance of the initiation of the movement (Rosenbaum, 1991).

Thus, if visual feedback and proprioceptive feedback can be used, then individuals might be instructed appropriately (1) how to use sensory information and (2) how to be aware of environmental cues to control their actions. In the first case, some sensory information is available prior to the movement, while other information is available during the action. Before the movement begins, learners can use relevant visual signals to assist in directing their actions. Also during or after the movement, feedback can be used (Winstein & Schmidt, 1989). For example, feedback can be contributed by specific receptors that are located in the muscles, joints, and tendons that indicate how the movement is going and if modifications are needed.

In the second case, specific cues in the environment may be used to guide the movement. For instance, the squash player can focus on a location on the front wall to aim the ball at.

In most learning and performing situations, many external and internal cues are potentially available to yield essential information. The challenge is to determine the most minimal, relevant cues at a particular time immediately prior to and during an act. For example, while a racquetball player serves the ball, he/she can feel the movement, and be aware of body parts, their location and timing, in relation to the requirements of the objective. There is visual information as to where the ball landed on the front wall, with what force, and what happened afterwards. Finally, it is possible to attempt to listen to the sound generated either by the racquet (when the ball hits the racquet) or by the wall (when the ball hits the wall) to evaluate the quality of the serve.

In another situation, a jockey may be aware of his/her riding position or the distance between his/her horse and the other horses to plan a new strategy. In these cases, there is a deliberate awareness of specific cues in the situation in order to assess how well one is performing, and whether to make any subsequent modifications. It appears that different sources of information can be used to advantage during performance. These sources are dependent upon (1) the task to be performed, (2) the environment, and (3) the ability of the learner to perceive relevant information at the right time as well as to use it to initiate appropriate actions.

In summary, although one of the primary goals in high-level performance is to attain a state of automaticity and nonawareness, it appears that the ability of being aware of the situational information can result in better achievement. In the next section, the characteristics of an awareness strategy will be reviewed. More specifically, two main topics will be discussed (1) how learners might be instructed to develop awareness of self, task, and situation while performing and (2) what the mechanisms are that are involved in the use of proprioceptive feedback.

Awareness Instructions

During the very first phase of learning and before practice begins, instructors should direct learners what to do (Newell, 1981; Norman, 1976). Obviously, this information is essential and critical in virtually any learning situation. Beginners will not able to initiate, let alone complete the task successfully, without adequate directions as to what is expected of them. For example, Judd (1908) suggested that instruction was necessary to realize fully the potential of utilizing knowledge relevant to certain principles of action. He provided an explanation of principles about transfer conditions for dart-throwing to an experimental group, while the second group served as a control. No differences in performance between the groups occurred for the first dart-throwing task. However, when subjects were asked to perform the task under different conditions, to transfer, the experimental group outperformed the control group.

On the basis of Judd's (1908) research, it can be argued that specific instructions can assist individuals to transfer better from one learning situation to another. In addition, good instructions should decrease learning time. They help to prevent the formation of bad habits (Welford, 1958). Moreover, relevant pre-training information should lead to better achievement since learners will be familiar with the task and know exactly what is expected of them (e.g., Batting, 1956). Unfortunately, very few systematic attempts have been conducted to examine the influence of instruction on skill learning (Newell, 1981). Furthermore, not much is really known about how to best direct learners to be aware of what need to do during the actual performance. Beginners are typically told to follow particular instructions while attempting to learn a task. In most cases, the standard form of guidance directs learners what to do in terms of movements and tactics. However, lacking is the information for the individual as to how to approach the task during execution; i.e., what to think about.

It is true that Batting (1956) found that verbal pre-training facilitated performance in a simple motor task but not in a complex one. Also, Renshow and Postle (1928), while administering a tracking task to two groups of subjects (instructions and no-instructions), reported that (1) during the first day of practice the uninstructed group was slightly better than the instructed group and (2) by the fifth day the scores of the uninstructed subjects were about three times as high as those subjects receiving instructions. However, it appears that most research on the influence of pre-training instructions on achieving in simple and complex motor tasks has shown that performance is facilitated (e.g., Davies, 1945; Gagné, Baker, & Foster, 1950). Davies (1945) demonstrated that subjects receiving systematic instruction in learning archery accomplished greater proficiency than control subjects.

In an earlier study, Goodenough and Brian (1929) gave three different sets of instructions to subjects. The subjects in one group did not receive any instructions, while subjects in another group were administered a brief preliminary demonstration and a subsequent verbal feedback of the general types of errors made. A third group was provided with same set of instructions as the second group as well as was taught to follow a specific procedure in throwing. The greatest amount of improvement was shown by the third group, followed by the second group. In this study, subjects in the second and third groups received (a) additional but essential information about the task and (b) directions (although indirectly) as to how to be aware of the correct way to execute the movements (throwing rings over a post).

In a similar study, Parker and Fleishman (1961) also manipulated three different sets of instructions. However, they emphasized the importance of task-analysis. In this experiment, subjects in one group received only a brief description of the task with no formal training, while subjects in another group received explanation, guidance, assistance, and critiques of performance (a "common-sense" program). A third group of subjects, in addition to the instructions which were given to the second group, were instructed how to use special ability demands of the task to develop special training procedures. The authors found that subjects in the third group performed better than subjects in the second group, who performed better than subjects in the first group. Apparently, directing learners how to use specific cues and details that are related to performance may lead to a better understanding about the task. In other words, if subjects are able to use more sources of information during performance and are instructed how to become aware of them, better performance can be achieved.

In another study, Hendrickson and Schroeder (1941) compared three different sets of orientations: no directions, elementary explanation, and additional information about the task. Subjects receiving elementary explanation were directed how to perform the task. Subjects in the additional information group were given details and cues about how to apply the task. Both experimental groups learned more rapidly than the control group, and the additional information group outperformed the elementary information group. These results indicated that the more details subjects are aware of, the better the performance.

Research has been initiated earlier in this century in which subjects were asked indirectly to pay attention to and to be aware of what they were doing in learning situations. Cox (1933) directed a group of children and two groups of adults to perform an industrial task (assembling, wiring, and stripping an electrical lamp holder). The children and one group of adults were given a general explanation about the task. The other adults were instructed to pay attention to the (1) manner of holding the parts, (2) visual and kinesthetic cues, and (3) control of attention and effort. Subjects who used visual and kinesthetic cues performed better than the subjects who were given general instructions. Although there were some methodological problems with this study (e.g., the instruction was included in such a way that the group receiving it was allotted additional time), it seems that Cox's findings have added another dimension to the investigation of instructional programs. Various kinds of instruction were compared to make learning more meaningful. Performance in a motor task was facilitated best when kinesthetic and visual cues were emphasized.

From another perspective, Holding and Macrae (1964) showed that physical guidance, as a way of directing students how to perform a task, can help to develop skill. It is not uncommon, for example, for a tennis coach to take the arm of a player learning tennis, and to guide it through the desired movement pattern. By following this procedure, learners may increase their movement awareness of the correct way to execute the skill. Not only may direct and indirect instructions develop awareness in learners. It may also be developed when learners talk to themselves about the directions/instructions that were introduced before practice began. Holding (1965), for example, has postulated that at the very early stage of practice, better beginning learners tend to mutter to themselves. By doing this, they may increase their awareness of the (1) instructions, (2) specific demands of the task, and (3) particular ways in which the potential number of errors may be reduced.

Also, practical advice (not necessarily based on research evidence) has been offered as to how awareness of performance can lead to better achievement. Gallwey (1981) has proposed that a good instructor is "one who engages the student in learning from experience and increases his self-trust" (p. 12). Gallwey called this "awareness instruction" and defined it as a mode of learning in which individuals are requested to attempt to feel what is happening. He proposed that learners should be asked to (1) feel their movements, (2) listen to the sound of the happening event, and (3) pay attention to the direction of the movements.

Feldenkrais (1972) has emphasized the state of awareness during performance to "gain control of muscles, emotions, and thoughts and integrate them into a smooth performance" (p. 151). By undertaking a set of routine exercises, individuals are asked to feel the movements and the muscles tone, and to think about the courses of action in which they change positions and move the body.

So far, an attempt has been made to describe awareness instructions and awareness at the beginning of the learning process. However, it also seems that experienced performers, if instructed to do so, are able to develop a state of awareness during performance. Ravizza (1986) has stated that the skilled athlete should "be encouraged to become aware of his or her own ideal performance state and routine behaviors..." (p. 151), to focus attention on the task. According to Ravizza, awareness is developed in sport, and experience and practice can help athletes to be aware of their optimal emotional and arousal levels. In addition, it has been shown by Laszlo and Bairstow (1983) that kinesthesis sensitivity can be trained, and that once kinesthetic awareness has been established, the ability to use kinesthetic information is retained.

In summary, it appears that beginning learners and advanced learners are able to develop the ability of being aware of what they are doing during performance by using proprioceptive information effectively. The activation of appropriate proprioceptors, for example, can help individuals to feel what they are doing and how to control their movements. Discussion on the use of proprioception, and the mechanisms involved, will be included in the next section.

Proprioception Defined and Mechanisms Involved

The term, proprioception, will be used in this investigation as a global concept which includes the activation of kinesthetic mechanisms as well as proprioceptive mechanisms (Hopkins, 1972). Although different mechanisms are involved in the use of kinesthetic feedback and proprioceptive feedback, similar information can be perceived.

Proprioception involves the sense of movement along with the sensing of tensions, forces, pressures, and body orientation in space (Winstein & Schmidt, 1989). Additionally, it contributes to effective movement's production in terms of speed, distance, locomotion, and overall body coordination (Howard & Templeton, 1966).

There are three types of joint receptors, a vestibular apparatus, and proprioceptor providing proprioceptive feedback (Kelso & Stelmach, 1976; Skoglund, 1973):

1. Golgi-tendon organs, which are located in the ligaments, and signal joint position as well as direction.

2. Ruffini endings, which are located within the joint itself, and signal speed and direction. They may also signal resistance to movements and perhaps discriminate active movement from passive movement.

3. Pacinian corpuscles, which are located in the capsule of the joint, and may be capable of detecting very small movements as well as movement acceleration.

4. The vestibular apparatus of the inner ear provides signals related to movement in space.

5. Proprioceptors are located between the outer and inner surfaces of the body in the muscles, tendons, and joints. The stimulation of these receptors provides information about tension, force, pressure, and bodily orientation in space.

These mechanisms assist individuals to use information to control different parameters of motor control. The usefulness of this information in human movement control is discussed next.

The Role of Proprioception in the Control of Motor Performance

Although Kelso, Holt, and Flatt (1980, Experiment 1) have shown that joint afferent information is not crucial for movements involved in flexion of the index finger, it can be argued that proprioception plays an important role in movement control and error detection. Singer (1980a) has stated that kinesthetic cues, for example, are of secondary importance in simple tasks, such as the one described by Kelso et al. (1980) or in aiming tasks. However, in more complex motor performances, such as athletic skills, kinesthetic cues seem to be more meaningful. Performers can use these cues as a source of information (e.g., the distance and end location of the movement) during performance.

Laszlo and Bairstow (1983) have shown that proprioception is essential for the learning and performance of complex ballet skills, and that the quality of performance depends on both the control of muscles and the use of proprioceptive information. They have reported that a ballet dancer demonstrates a high sensitivity to proprioceptive information (Laszlo & Bairstow, 1983, Study 2).

Laszlo and Bairstow's findings have been observed by other researchers. In an early study, Fleishman and Rich (1963) studied the relationships among performance in a coordination task, a kinesthetic sensitivity test, and a spatial-visual orientation test. Subjects were pretested on a kinesthetic sensitivity test, and a spatial-visual measure, and then completed 10 blocks of 4 trials each in the Two-Hand Coordination Test (THC). An analysis of data revealed that the spatial measure was significantly related to performance of the THC only early in practice. The kinesthetic measure was significantly related to THC performance but only late in practice. Additionally, subjects with high kinesthetic sensitivity became increasingly better in the task than subjects with low sensitivity. These results were also supported by Gibbs (1965). In Gibbs' study, subjects were asked to make rapid movements in the opposite direction to stop functional signals. Early in practice, the mean time to correct the errors was longer than the time needed later in practice. According to Gibbs, the ability to correct errors at the latter phase of learning is due to proprioceptive correction and not visual correction. In this stage of practice, the movement is made too fast to be corrected by visual feedback.

In another study, Notterman and Page (1962) have used a computer tracking task to manipulate the degree of elasticity of a moveable control stick. It was found that subjects who were able to use proprioceptive feedback arising from the most moveable stick performed better than subjects who could not use any proprioceptive feedback. Although sparse data exist about performance awareness of muscle tension (Clark & Norch, 1986), it appears that proprioceptive feedback plays an important role in late more than early stages of learning as well as control of motor skills. In early stages of learning, beginners depend on visual feedback more than any other source (Christina & Corcos, 1988; Schmdit, 1991). Since the pattern of the desired movement has not been acquired yet, individuals must watch the activity to control their actions. Furthermore, they may also rely on external feedback which is given by instructors to correct any potential errors (Singer, 1980a). However, when the pattern of the movement has been achieved, the visual feedback may be withdrawn and proprioceptive feedback can be used more effectively.

In this context, in many sports skills, the execution of the movement may be carried out without visual feedback (Dickinson, 1976). In a basketball game, when the point guard dribbles the ball and sets up the offense play, he/she does not have the time (nor the need) to look at the ball to see where it is. If he/she does so, vision and attention will not be free to control other essential activities, such as determining when to pass or to shoot. Thus, the skilled point guard uses proprioceptive feedback at a sub-conscious level to feel the ball and to control the speed, height and the location of the dribbling.

By using proprioceptive feedback, learners seem to increase their awareness to an on-going activity. Paying attention to details and thinking of the act during execution may assist them to attain a higher level of skill. However, there are other alternatives as to what think about during movement execution. For instance, in sport, music, and dance paying attention to the act during the actual performance may cause performance to deteriorate. Potentially, dividing attention among situational cues or shifting attention from one source to another can slow down the action and increase number of errors. Moreover, after extensive practice has been undertaken, performers should not need to focus their attention of what their are doing, thus freeing this capability to process other information. This state of performance, the nonawareness approach, will discussed next.

The Nonawareness Approach to Learning and Performance

One of the characteristics that seemingly is related to excellence in the execution of any sport act appears to be performance without deliberate conscious attention to self or situation. Furthermore, more complicated externally-paced activities, as in on-going tennis play, require the automatization of routine skills so that attention can be freed for anticipation and decision-making. According to Bloom (1986), the mastery of any skill, whether a routine daily task or a highly-refined talent, depends on the ability to perform it as if sub-consciously, effectively meeting the challenge of the situation with minimal effort.

When performers attain a state of automaticity, it appears that they do not have to think about what they are doing, and movements are sub-consciously executed.

Generally, when skilled athletes, dancers, or musicians are asked afterward what they thought about during their best performances, they typically report that they remember very little. After initiating the activity, the body seems to take over and everything "just happens". They "relax their mind" and perform with minimum conscious effort.

In exploring the state of mind associated with this feeling, sport psychologists (Loehr, 1982; Suinn, 1976) agree that words and phrases, such as automatic, unconscious, without thought, and focus on the present, characterize athletes during peak performance. Garfield and Bennett (1985) have suggested that athletes lose all conscious thought of what has been learned about "how to use the mind and body" (p. 179) when they perform at their best. They use the term "letting go" to indicate the mental state that athletes experience, and point out that learning to "let it happen" rather than "trying to make it happen" is the major step to achieve this performance state.

Apparently, athletes have minimal thoughts about what they should do or how they should do it during an outstanding competitive performance. They may feel (1) isolated from all distractors, (2) so involved in the action that there is not even a question of confidence or the lack of it, and (3) have all the time they need to respond accurately. According to Singleton (1988), tennis players learn to relax and let their "mind function to its ability"

(p. 50). He recommends that athletes should not think about their strokes when they play. They should relax and "let their mind automatically make the shots" (p. 50).

When working with tennis and golf players, Gallwey (1976, 1981) has observed that players develop a unique approach during practice or a match: They hit the ball through an automatic process that does not require thinking. The athletes may be aware of the sight, sound, or the tactical situation but they seem to know without thinking what to do. They are not trying to hit the ball and thinking about how badly or how well they made contact. Based on this state, a mental technique associated with the ability to perform skills (such as serve in tennis) without thinking about or being aware of the actual act was developed by Gallwey (1976).

Excellence in performances has been studied in other situations besides sports. By asking people to think out loud as they attempt to solve a problem, it is possible, for example, to study how they use their knowledge in playing chess or solving physics problems (Good & Brophy, 1990; Welker, 1991). Research in this area involves comparing the thinking of skilled and experienced experts with that of novices. The purpose of this kind of investigation is to describe "how the experts do it", and to identify the nature of the problems that the novices experience (Greeno, 1980). Such knowledge can be used as a basis for instruction designed to move novices toward expert status more quickly, by teaching them to think as experts do, and to teach them to achieve more expediently.

Expert-novice studies have shown differences in problem perception. Experts respond faster and more accurately than novices do when the knowledge is relevant in specific situations (Good & Brophy, 1990; Welker, 1991). For example, expert chess players perceive board positions of actual chess games in terms of patterns of board arrangement, whereas novices can not construct this arrangement and try to keep track of each individual piece (Chase & Simon, 1973). It seems that experts preplan their journey and are able to see the "whole picture" while novices may depend on specific cues and must think about each position separately.

Good and Brophy (1990) have pointed out that experts bring a much broader, deeper, and better organized body of specific knowledge to problems than novices do. They do it by relying on chunking strategies and by activating familiar strategy schemes. Novices tend to focus on specific features of problems and try to link them to specific information stored in memory. Additionally, experts have extraordinarily fast and accurate pattern recognition capabilities for these specific activities.

In this regard, a provocative question is whether relative beginners should try to perform without deliberately attending to what they are doing. Can they copy the mode of operation of skilled performers? Do they need to go through awareness stages before performance as if automatic can be realized?

Researchers in motor learning as well as instructors of skills have not addressed these considerations in any meaningful way, thus far. Although (a) athletes have described how at the moment of peak performance they felt consumed by the momentum of the event itself, and how their minds and bodies performed like instruments perfectly tuned to the moment, and (b) attaining a state of automaticity in routine acts is a goal in any mastery situation, lacking is any scientific evidence to understand this state or to help beginners to attain it. Hence, prior to discussion of the current approaches of studying automaticity, concepts and orientations will be addressed.

Automaticity in Skilled Performance: Concepts and Orientations

The term automatic (or automatization, according to Shiffrin, 1989), has been defined and interpreted in various ways in the cognitive psychology as well as in the motor control literature. Although there is agreement that tasks are performed without awareness or attention to details, there is a difference of opinion as to how these definitions are interpreted.

When summarizing research on automatic processes, Logan (1985, 1988a, 1988b) has described automatic performance as fast, effortless, autonomous, stereotypic, and unavailable to conscious awareness. In addition, he indicates that automaticity is acquired only in consistent task environments, and sufficient and effective practice in such environments develops most properties of automaticity (Logan, 1988b). Highly-skilled performers are able to execute movements appropriately without being aware of actually controlling them. The ability to process information is fast and effortless since performance is not subject to attentional impositions and limitations.

Norman and Shallice (1986) pointed out three different meanings of the term. First, there is the way that certain tasks can be executed without awareness of what is happening. In this case, the performer controls the action so well that he/she is not aware of doing it (as in walking along the beach). Second, actions may be both initiated and performed with deliberate attention or awareness. The individual knows what he/she is doing, but does not think about it (as in moving one's arm away from an insect). Third, there are cases in which one can be passively aware of performing the actions, but without paying attention to any of them or with any attempt to control them, as in athletic events. For example, the tennis player knows what techniques and mechanics should be applied while executing the serve. However, he/she does not focus his/her attention on them.

Although, the distinctions among these three meanings of automaticity are not very clear, and not many examples can be given to illustrate the differences among these views, Norman and Shallice (1986) emphasized that an automatic task is performed without awareness of what is happening. That is, the performer knows what he/she is doing but controls the action so well that thought processes are not involved.

From another perspective, Posner and Snyder (1975) have also suggested three criteria that must be met in order for a process to be classified as automatic: (1) it must occur without intention, (2) it should not give rise to any conscious awareness, and (3) it should not interfere with any other ongoing mental activity. The second and the third criteria are well-explained by Posner and Snyder; however, it appears that the first criterion is not well-understood. To explain the third point, it can be argued that by performing the act automatically, cognitive processes may not be involved. Thus, it appears as if it is executed without intention. At least one point in Posner and Snyder's interpretation should be emphasized. If the task is performed without conscious attention, then another task can be completed without interference. In other words, two tasks can be successfully performed simultaneously.

In summary, automatization in performance may lead to executing a task without awareness, without attentional control, and with unintended focus of attention. In addition, automatic processes can be characterized as fast, accurate, and effortless. These interpretations of the term will be used throughout this paper. Of special interest will be the consideration of accuracy, speed, and effort of movement in two types of self-paced tasks, ball-throwing and key-pressing, to be studied in this investigation. An important point to note is that several approaches have been taken to explain features of automatization, and different research paradigms have been generated to study this topic. Although conclusions are similar, the tasks and conditions in each approach are not alike.

Although this particular investigation is concerned with the learning and performance of motor skills, it is relevant to discuss research on paradigms using cognitive tasks for two primary reasons: (1) when performing motor tasks, cognitive processes (e.g., how to be prepared for performing the task and how to perform the task) are involved and (2) according to researchers in cognitive psychology and motor control (e.g., Anderson, 1987; Crossman, 1959; MacKay, 1982), motor skills are acquired in a manner similar to cognitive skills. Hence, ideas that have emerged from memory search paradigms or the acquisition of computer languages can be applied to the understanding of the processes involved in the acquisition of motor skills.

Several paradigms and approaches have been used by researchers to study the characteristics of automatic processes. Automaticity is commonly viewed as a special topic in the study of attention (Logan, 1988a). Attentional processes (including automaticity) have been investigated with, for example, memory search paradigms (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), letter-matching tasks (Posner & Snyder, 1975), emotional and motivational considerations (Easterbrook, 1959), cognitive skills (MacKay, 1982), motor tasks (Crossman, 1959), and dual-task performance situations (Brown & Carr, 1989). Similarities and differences among these paradigms, and how they relate to automaticity, will be discussed next.

Controlled versus Automatic Processes

In attempts to study the structure and development of mental processes, two distinctions have emerged within the information processing conceptual framework: processing can be either controlled by the person and determined by the structural features of the system, or it can require either capacity or be free from task demands. In other words, processes can be controlled or automatic (Schneider & Shiffrin, 1977). Controlled processing is slow, serial, limited by short-term memory, demands effort, exhibits a large degree of personal control, and requires little or no training to develop. For example, trying to remember a telephone number is an example of a control process. On the other hand, automatic processing is a fast parallel process, not limited by short-term memory, requires little effort, necessitates extensive and consistent training to develop, and needs little direct personal control. Driving a car after sufficient experiences is an example of an automatic process. To study the characteristics of these processes, two different paradigms have been used by Posner and Snyder (1975), Schneider and Shiffrin (1977), and Shiffrin and Schneider (1977).

Posner and Snyder (1975) devised a letter matching task and a priming stimulus (either a plus sign or a letter) was followed by a letter pair. The subjects had to decide as quickly as possible whether the two letters in the pair were the same. Two basic predictions were made (a) the priming stimulus automatically activates its own representation in memory and (b) conscious attention speeds up decision-making when an expected event occurs, and slows it down when the unexpected happens. It appears that a decision about any component of the task is easier if the performer knows in advance what is going to occur. When performing a self-paced motor task, for example, learners know exactly what is expected of them, and there is time to prepare the execution. Thus, an appropriate decision about the task can be made. For instance, before throwing a ball at a stationary target, an appropriate cue on the target can be focused on. If the same task is repeated, it will not be difficult to determine the appropriate target cue.

Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977) have conducted experiments using a memory search paradigm. In these experiments, target letters (either one, two, or four) were presented on a computer screen followed by either one, two, or four letters. Subjects were required to respond by pressing a "yes" button if the letters presented a second time were the same as on the first occasion. Additionally, if the letters were not identical, a "no" button was to be pressed. Two conditions were administered (a) consistent mapping and (b) varied mapping. With the consistent mapping condition, a letter in the frame was either always a target or never a target. In the varied condition, on some blocks of trials, a given letter in the frame would sometimes be a target, and on other blocks of trials it would not be a target.

The constant mapping condition can be interpreted as a consistent task environment, as Logan (1988a) pointed out. Research has established that practicing the task under the same conditions or in a constant environment leads to better performance (e.g., Fitts & Posner, 1967; Schneider, 1982, 1985). Hence, the time to initiate the task will be shorter if learners practice under consistent conditions. Clearly, this notion can be applied to the performance of self-paced motor tasks (which are executed the same way and under similar circumstances).

In contemporary theories of automaticity, similar paradigms have been used to postulate how cognitive skills are acquired and how these skills are executed automatically. An overview of four of these theories will be discussed briefly, and their implications to this study will be elaborated upon. The theories have been proposed by Anderson, (1987), Logan, (1988a), MacKay, (1982), and Newell and Rosenbloom, (1981). The theories of Anderson, Logan, and MacKay can also be applied to the acquisition of motor tasks. However, the Newell and Rosenbloom theory, which is based on chunking processes, is difficult to apply to motor skills. However, it can be used to explain cognitive processes used in dual-task situations.

Contemporary Theories

Anderson (1982, 1987) postulated an adaptive control of thought (ACT*) theory, which attempts to account for all cognition processes, including memory, language, learning reasoning, and decision-making. A basic distinction between declarative and procedural knowledge was made. Declarative knowledge is knowledge about facts, and procedural knowledge is knowledge about how to do things (Anderson, 1990). Facts are presumably encoded in a propositional network, and procedures are encoded as productions. Skill is demonstrated when knowledge proceeds from the declarative stage to the procedural one. This process includes several steps, and through practice, the performer is able to (1) reduce a complex procedure to a single step and (2) increase the speed with which productions are executed. To transfer knowledge from one situation to another, similar conditions of the tasks should be shared.

According to Anderson, this model can be applied to the acquisition of cognitive skills as well as motor tasks. Hence, learning the tasks to be used in the present research, key-pressing and ball-throwing, can be explained by the ACT* model. For example, subjects in the Five-Step Approach group will have to transfer the knowledge they acquired while listening to the Five-Step Approach instructions (declarative knowledge) to ball-throwing performance (procedural knowledge). In this case, basic information about the strategy (e.g., what steps to follow), would be transferred to a situation in which subjects need to determine how to apply it in preparation for and while they are throwing balls at the target.

According to Logan (1985, 1988a, 1988b), automatization will exist only after sufficient practice occurs in a consistent environment. During practice, a "domain-specific knowledge base, formed of separate representations, instances, of each exposure to the task" (Logan, 1988a, p. 492) will be acquired. A process is considered to be automatic if it relies on retrieval of stored instances. That is, automaticity is memory retrieval: performance is automatic if learners are able to recall past solutions from memory. During the learning process, individuals gain experience and they learn specific solutions to specific problems. Thus, they can respond to a stimulus with a solution retrieved from memory. Practice is important because it increases the amount of stored instances, as well as the speed of retrieval. Based on this theory, novice performance is limited by a lack of knowledge.

MacKay (1982) has proposed a theory in which learning occurs by strengthening connections between nodes in a network. It describes the mechanisms and processes underlying perception and action. Two assumptions were required. First, the connections between nodes are strengthened in proportion to the difference between the current strength and the maximum possible strength. Second, higher nodes are smaller in number and farther from their maximum strength than the lower nodes.

For the purpose of this investigation, two implications may be considered (a) early learning would be dominated by greater changes in the strength of a few higher nodes, and later learning would be dominated by small changes in the strength of all nodes and (b) practice strengthens connections between stimuli and responses (MacKay, 1982). It is obvious that both the Logan and MacKay theories are relevant to the process of motor skill acquisition. In both theories, the emphasize is on practice and constant environment situations.

Newell and Rosenbloom (1981) and Rosenbloom and Newell

(1986) have proposed a theory called the chunking theory of learning. They assume that learners acquire responses to stimulus patterns or chunks which they can execute the next time the pattern occurs. Higher-level, large-sized chunks are built from lower limit chunks, and therefore are learned later than lower level chunks. The authors state that performance time decreases as a power function of practice because of the increasing specialization of higher level chunks.

Newell and Rosenbloom's theory (1981) is presented in this paper because elements of chunking are apparently involved in the secondary task of the dual-task situation tested in the two experiments of this study. For instance, in Experiment 2, subjects are asked to memorize 6 letters that are presented on the monitor, and then to call them out while performing the key-pressing task. It is believed that one of the ways to remember these letters is by chunking them. Thus, performing the secondary task better may be attributed to the appropriate use of the chunking process. Besides the four models just described briefly, other scholarly efforts have been generated more particularly for the understanding of motor performance. They will be discussed to provide a more comprehensive perspective about the nature of automaticity.

For many years, Crossman's theory of the acquisition of 'speed-skill' has been accepted as an explanation of task-improvement with practice (Crossman, 1959). Subjects sampled methods for performing a cigar-making task until they found the fastest one. At the beginning of the learning process, Crossman suggested that there is a pool of possible methods that people can select. Several methods are randomly tried out, and only the fastest would have the highest probability of being used in the long run. Practice helps learners to select the appropriate method, and increases speed of production. The theory predicts improvement with practice because each method is selected according to a probability, and these probabilities are adjusted on the basis of time saved relative to previously attempted methods.

Although the model proposed by Fitts and Posner (1967) has not provided an explanation of automatic processes, it can be considered as an attempt to describe how learners achieve a state of automaticity. They proposed three stages individuals go through from beginning to high-level performance: cognitive, associative, and autonomous. In the third stage of their model, some of the characteristics of automatic processes are described, similar to the ones discussed by Schneider and Shiffrin (1977). Component processes become increasingly autonomous, less apt to be under cognitive control, and less subject to interference from other ongoing activities or environmental distractions. In Crossman as well as Fitts and Posner's explanations, practice and experience with the task are the most salient requirements for attaining a state of automaticity in performance.

Considerations in these models are related to experience with a single task, and extensive practice with it. Another way to study characteristics of the process of automaticity is by asking individuals to complete two tasks simultaneously, typically, one of which has already been practiced extensively. To some scholars, this is the optimal situation to assess if the primary task is performed without conscious attention (Schneider, 1985). The nature of concurrent task performance, considered in dual-task paradigm, will be discussed next.

Dual-Task Paradigms

Dual-task methodology has been used in cognitive psychology and motor learning research in attempts to (1) describe the mechanisms, processes, and limitations of human attention and information processing (Korteling, 1991; Trumbo, 1977) and (2) determine whether subsequent performance in a secondary task, which is simultaneously practiced with a learned primary task, can serve to indicate the degree of learning in the primary task (Bahrick, Noble, & Fitts, 1954; Pashler, 1989).

In dual-task experiments subjects attempt to complete two tasks simultaneously. For example, a vocal response to an acoustic stimuli may be required while subjects perform a typing task (Brown & Carr, 1989); to execute a tracking task paired with a letter-typing task (Gopher, Brickner & Navon, 1982); or to tap rapidly with the index finger while reciting a nursery rhyme (Peters, 1977). Two primary findings have been emerged from these and other experiments (cf. Trumbo, Noble, & Swink, 1967). First, when the two tasks use the same resources (e.g., acoustic), performance decrements occur. Second, if the two tasks require different resources (e.g., acoustic and visual), then the two tasks can be executed nearly without interference.

In the first case, performing concurrent tasks may overlap in various degrees in their demands for capacities, thus increasing the total "load" on the person who is asked to divide attention to meet the specific demands of each task. Consequently, performance in one of the tasks (or both) may be hindered. In the second case, the paired tasks do not share the same resources, thus the tasks can be effectively performed without interference. For example, after considerable practice, an experienced driver can drive a car and listen to the radio at the same time.

These two points have also been elaborated upon by other researchers. Treisman (1969), for example, has suggested that two tasks will interfere to the extent that they make demands on the same set of perceptual analyzers, such as for shape, size, or color analysis, because a given analyzer is assumed to be a single-channel processor.

Kahneman (1973) has stated that interference is a result of simultaneous demands of two tasks on specific perceptual (auditory and visual) and motor mechanisms (muscles, joints, and body parts). According to Kahneman, the amount of interference should be proportional to the extent to which the sum of the demands of the tasks exceed the capacity of the attention system. Increasing processing load leads to a rise in arousal, which in turn permits the system to mobilize resources that were not available with a lower load. It is difficult to predict what is going to happen when two tasks are combined.

One of the important factors to consider when designing a dual-task research paradigm is the amount of practice to be administered. The general trend in the research is that, with practice trials, dual-task interference is reduced or may even disappear (Spelke, Hirst, & Neisser, 1976). Likewise, there is often little or no interference if at least one of the concurrent activities has been extensively practiced prior to the introduction of the dual-task performance arrangement (Shaffer, 1975).

Considering these perspectives, it would be of interest to determine if guidance in the use of a particular learning strategy can assist learners to achieve better in dual-task performance. Or, if a primary task has been learned to a high degree with a specific learning strategy, will such a situation enable a person to achieve very well even when a secondary task is introduced? So far, the effectiveness of learning strategies has only been investigated with a single task (e.g., Singer, DeFrancesco, & Randall, 1989).

Saying it another way, if a learning strategy is introduced prior to dual-task performance, two questions can be raised (1) are individuals, who are taught a strategy able to perform the primary task better while the second task is introduced than those who are not instructed to use any particular strategy? and (2) are they able to achieve better in the secondary task than individuals who have not receiving any particular strategy? An attempt will be made in this study to answer such questions.

To Be (Aware) or Not To Be (Aware)?

The effects of teaching depend not only on what the learner knows, (previous experience and knowledge), but also on how this information is applied in crucial situations (Wittrock, 1978). Thus, it has been advocated that instructors direct individuals how to think, and how to use task-relevant learning strategies. Three specific procedures can be advanced with regard to influencing thought processes during the learning and performing of self-paced motor skills: an awareness strategy, a nonawareness strategy, and the Five-Step Approach strategy.

Learners can be directed to be aware of what they are doing during learning and performance sessions. They might be encouraged to think about the activity and to pay attention to specific details and environmental cues. During execution, they would attempt to be aware of what each part of the body is doing, and to try to feel the movements. Alternatively, learners can be oriented to be unaware of what they are doing. Their thoughts can be directed away from the performance act, to pay little attention to situational details. Once developing an internal movement plan, they would let the movements flow without being aware of how they do it. They would attempt to relax and execute the skill as if in a state of automaticity.

On the one hand, Laszlo and Bairstow (1985) reported that the ability to feel movements and to use sensory feedback is essential in the acquisition of motor skills. By using this information, movements are controlled and errors corrected in future performances. In addition, if individuals are aware of what they are doing, and pay attention to specific details, they are presumably able to be more organized and motivated to acquire new knowledge (Weinstein & Mayer, 1986). Furthermore, learners may use cues and specific details as references for future tasks, which also assist them to reduce feelings of anxiety.

On the other hand, elite athletes typically claim that during peak performance, they did not try to pay attention to the way they executed. Moreover, they could not remember the act or event itself, and performed without thinking about it or allocating attention to it. Schneider and Fisk (1983), for example, reasoned that once subjects learned to "let go", they could perform a task with high accuracy, even while performing a high-work load task. Subjects could maintain performance while given extensive practice (e.g., up to 20,000 trials) as well as when asked to perform two tasks simultaneously. According to Schneider and Fisk, by "letting go", subjects perform a task without allocating any attentional resources to it.

In addition, Hebb (1961), Pew (1974), and Nissen and Bullemer (1987) found that subjects could learn a sequence, (e.g., nine digits), without being aware of what they were learning. In these studies, subjects reported that they were not aware of the repetitions in the series of the task. For example, in Hebb's (1961) study, subjects were instructed to listen and repeat a sequence of nine digits in exactly the same order. On every third trial, the same series was repeated, and the object of the experiment was to discover what effect this had. Subjects performed the sequence without paying attention to what they were doing. That is, they did not observe the repetition. Results showed that in spite of the lack of awareness, improvement in learning did occur.

The awareness state of learners has been the subject of interest in research on motor skills as well as in research on memory. Eich (1984) suggested that it is possible to distinguish the effect of memory for prior episodes or experiences on a person's current behavior from the person's awareness that he or she is remembering events of the past. Specifically, Jacoby and Witherspoon (1982) have shown that episodic-semantic memory is associated with the awareness state of the subject, and remembering without awareness is associated with memory for a particular episode.

Not only the influence of an awareness strategy versus a nonawareness strategy on the learning and performance of motor tasks was investigated, but they were also compared in effect with the Five-Step Strategy. Although there is evidence to show the usefulness of the strategy in motor task performance (e.g., Singer & Suwanthada, 1986), other strategies may be more beneficial. So far, the Five-Step Strategy has not been compared with other types of strategies. Nor has meaningful research been conducted with the other two types of strategies.

In this regard, three important questions can be asked. First, what is the best strategy (awareness, nonawareness, or the Five-Step Approach) for beginners to use during the learning and practicing of a task? That is, should learners try to be aware of what they are doing, or should they attempt to perform the task as if in a state of automaticity, or should they follow a more comprehensive strategy such as the Five-Step Approach? Second, since athletes report that during peak performance everything seems to happen automatically, without intentional awareness, are instructors able to guide beginners to think in the same way? Third, what is the best strategy to use in an attempt to ultimately attain a high state of achievement (related to automaticity) in the performance of a motor task?

CHAPTER 3

METHODS

Two experiments were conducted to investigate the problems posed in this research. In the first experiment, a ball-throwing task was administered. Studied was the influence of learning strategies on the attainment of skill in a sport-type task, which somewhat represented a real-life learning situation. In the second experiment, the learning strategies were investigated with a key-pressing laboratory task. In this type of case, the control over the testing situation is typically better, although the inferential potential of the data to real-life tasks may be more limited. The data from performance on two very different type of self-paced tasks provided a greater understanding about the general potential of the different learning approaches.

Experiments 1 and 2 are presented separately in order to provide a comprehensive overview of the methods.

Experiment 1

Subjects

Seventy-two students (36 females and 36 males), with a mean age of 20.13 (ages ranged from 17 to 35) enrolled in sport and fitness classes at the University of Florida, were asked to volunteer to participate in this experiment. The subjects were to have no prior knowledge about the nature of the study, the hypotheses, or the nature of the task. The number of subjects assigned to each treatment cell was determined by using Cohen's (1988) tables. The values used for entry into the table were as follows $\underline{a} = .05$ (level of significance), $\underline{u} = 3$ (k-1), $\underline{f} = .40$ (value for large effect size), and a power of .80. Based upon the specifications for this study, a table value of $\underline{n} = 18$ was obtained. Thus, 18 subjects were randomly assigned to each of the four learning situations: awareness, nonawareness, Five-Step Approach, and control.

Apparatus

The same target throwing apparatus that was developed by Singer, Cauraugh, Murphey, Chen, and Lidor (1991) was used in this experiment. The target apparatus was 65.45 cm in diameter and mounted on a 1.22 m x 1.22 m square board. The board was positioned upright on the floor 3.66 m from the throwing line (white tape on the floor). Narrow electrical wires were placed in concentric circles and positioned just above the target's metal surface. The target center was 7.61 cm in diameter and each of the 16 concentric wires were spaced equally (1.90 cm) across the metal. Seven white lines (5 cm in width), also marked with white tape, 45 cm from the target, and 10 cm between each, were marked on the floor to help subjects aiming. Figure 1 shows the target apparatus and a subject at the throwing line.

The target was connected electronically to a Cyborg ISSAC A/D and D/A system and an Apple IIE microcomputer. The microcomputer was programmed to run the experiment and collect the data. When a ball contacted one of the wires, it was depressed against the metal and an electrical circuit was completed. The ISSAC system recorded the specific wire that was activated, and the computer stored the value of that particular wire. A ball hitting the center of the target was scored as 1 point, and tosses hitting farther from the center of the target were scored with higher point values (increased by 1 for each wire). The most distant wire was scored as 16. Balls that failed to strike the wires on the target area were recorded as a 20.

Two light emitting diodes (LEDs) were mounted at the top-center of the target board. The microcomputer activated these lights at regular intervals. The red LED indicated a "preparing to throw interval" and the green LED signaled a "throw interval."

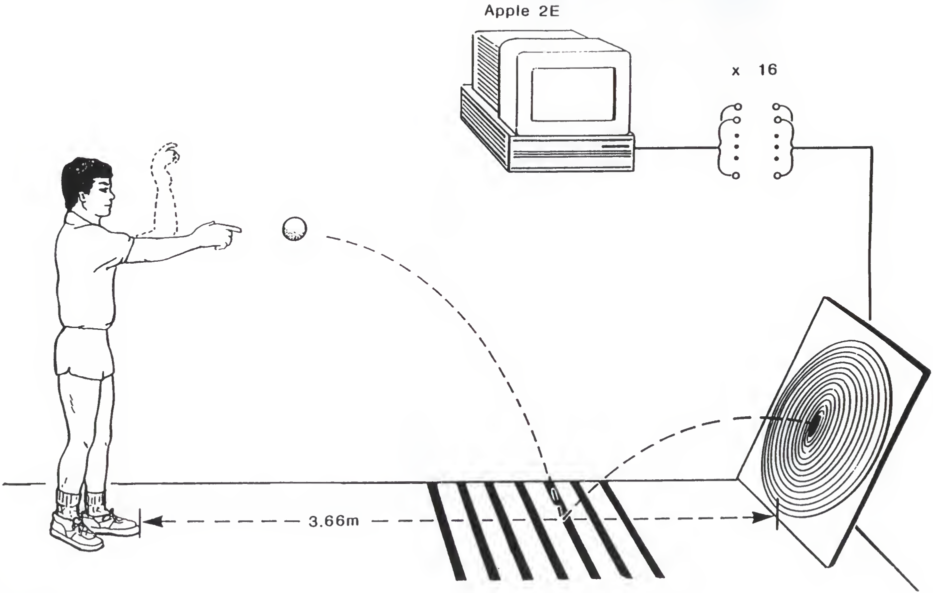

Figure 1. The apparatus and a subject at the throwing line.

Tasks

Subjects were instructed to throw the paddleballs (3.8 cm in diameter) at the target with one bounce on the floor before target contact. They stood behind the throwing line and tossed the ball with their nondominant hand (in an overhand motion).

During the last 50 trials (the second part of Day 2), subjects simultaneously completed the throwing-task and a verbal task. The verbal task required subjects to call out a specific number from a sequence of 5 one-digit numbers, determined randomly, which was presented by audio cassette.

Procedure

Upon arrival at the Motor Behavior Laboratory, subjects completed an informed consent form (see Appendix A), and a demographic questionnaire in order to obtain background data such as the gender, date of birth, vision ability, and dominant hand of the subjects (see Appendix B). Testing took place in a separate enclosed room.

The experiment was conducted over two days. One hundred and twenty-five ball-throwing trials were administered during the first day. This testing session took about 40 min. On the second day, 125 trials were administered again. A 5-min rest was given to subjects followed by 50 trials in a dual-task performance situation. This testing session took about 1 hr.

During the first day of testing, two sets of instructions were presented on tape: general and specific. The general set of instructions (same for all subjects) introduced the subjects to the Motor Behavior Laboratory, and described, in general, the research activity undertaken in the lab. In addition, an explanation of how to perform the ball-throwing task was given. It took 7 min to listen to the general set of instructions.

Following the general set of instructions, a specific set of directions for the awareness, the nonawareness, the Five-Step Approach, and the control groups was presented on tape. Subjects in the awareness group were instructed to be aware of the way that they threw the ball at the target, to pay attention to specific cues, such as the noise generated by the ball after it hit the target, and to "feel" the movement (for example, to feel how the arm moved during a throw). The nonawareness subjects were told to focus on a specific cue, such as the center of the target (the inner circle black spot), to relax, to preplan the movement, to let the throwing movements flow, and to perform the task as if in a state of automaticity.

Subjects in the control group received additional information about the task and the importance of the study. For example, subjects were reminded to throw the ball when the green light came on or to pick up only one ball each time they performed the task. It took about 2 min to listen to the specific set of directions for the awareness and the nonawareness groups, and 70 s to the specific directions for the control group. A complete set of instructions for each of the three conditions (awareness, nonawareness, and control) is provided in Appendix C.

The same set of instructions for the Five-Step Approach that was administered by DeFrancesco (1989) was used in this study. Subjects were instructed to apply the 5 steps: readying, imaging, focusing, executing, and evaluating (see Appendix D). It took about 10 min to listen to the Five-Step Approach directions.

As has been pointed out in Chapter 1, the Five-Step Approach contained awareness and nonawareness orientations. For example, the 2-min instructions on how to execute the task (in the fourth step) were similar to the ones given in the nonawareness condition. Hence, the allotted time for the nonawareness (2 min) as well as the awareness (2 min) conditions was given in relation to the time spent on them in the Five-Step Approach instructions.

Before testing began, subjects had 5 practice trials. The 125 trials were given in 5 blocks of 25 trials with 50 s rests between blocks. After every 10 trials, a specific strategy reminder was given orally by the experimenter. Subjects in the awareness group were reminded to pay attention to details, to be aware of the way that the movement was executed, and to "feel" the movement. Subjects in the nonawareness group were reminded to relax, to focus on a cue on the target board, and to perform the task as if in a state of automaticity. The Five-Step Approach subjects were told to use the five steps: readying, imaging, focusing, executing, and evaluating. Subjects in the control group were reminded to try to do their best.

During the second day of testing, subjects heard the specific set of task instructions again. No practice trials nor strategies directions were given before they performed the 125 trials. The rest interval and the strategy reminders were presented the same way as the first day. At the end of the 125 trials on Day 2, a 5-min rest was provided. Subjects were asked to sit on a chair in the testing room. The experimenter stayed with them, and initiated a general conversation about their program, classes, and school-work. An additional 50 trials were then administered in the dual-task situation. Instructions for the dual-task trials were verbally presented by the experimenter. Subjects were asked to perform two tasks simultaneously. In addition to the ball-throwing task, subjects performed a verbal task.

A similar verbal task that was used by Trumbo (1977) was administered. The task consisted of a sequence of 5 one-digit numbers, which were selected from the numbers "1" to "9", randomly generated over a speaker. Subjects listened to the sequence which was initiated each time that the green light came on. The experimenter asked subjects to call a number out as quickly as possible after the fifth number in the sequence was presented. It took about 3 s to present each one of the sequences.

When the red light came on, subjects threw the ball at the target. Thus, either during or immediately after the throwing motion the subjects called the specific number. For example, a subject might have heard the sequence 3, 6, 1, 7, 4, and was asked to identify the second number. In this case, the subject had to call the number "6". The numbers to be called out were randomly changed across trials, thus subjects were not able to anticipate them. A list of the 50 sequences is provided in Appendix E.

At the end of the second day of testing, a questionnaire was given to the subjects (see Appendix F). The data obtained from this questionnaire were used as a strategy check. Subjects in the awareness, nonawareness, and Five-Step Approach groups were asked if they used the suggested strategies during their experiment, and to what extent. Those subjects who did not use the suggested strategies were instructed to describe the type of strategy they used. Subjects in the control group were asked to explain the type (if any) strategy they used.

Experimental Design

Separate 4 x 2 x 5 (Groups x Days x Trial Blocks) ANOVAs with repeated measures on the last two factors were conducted for the first 10 trial blocks. The last 2 trial blocks which represented dual-task performance were analyzed in separate mixed design analyses. Absolute constant error (ACE) and variable error (VE) were the dependent measures as well as the number of bull's-eyes.

The analysis of the VE data provided information about the consistency of the throwing task performance. The ACE analysis indicated how accurate the subjects were. The direction of the throws, e.g., too high or too low, was not of concern in this study, thus ACE (and not CE, for example) was of interest.

A one-way ANOVA was used for analyzing the number of bull's-eyes (when the ball hit the center of the target) for each group. The number of bull's-eyes was analyzed because the ultimate purpose of the task was to hit the center of the target (as in other throwing tasks). Thus, information on the ability of the subjects to aim at the center of the target was obtained.

In addition, the number of errors (for the verbal task) in the dual-task performance was analyzed with a one-way ANOVA. The analysis of these data provided information on how accurate the performance of the secondary task was, and therefore how consciously involved the subject was in attempting to respond. Alpha was set at .05 for all statistical analyses.

Experiment 2

Subjects

Sixty-four students (32 females and 32 males), with a mean age of 20.53 (ages ranged from 17 to 36) enrolled in sport and fitness classes at the University of Florida were asked to volunteer to participate in this study. None of the subjects had any prior knowledge about the nature of the study, the hypotheses, or the nature of the task.

As in the first experiment, the number of subjects assigned to each treatment cell was determined by using Cohen's (1988) tables. The values used for entry into the table were $\underline{a}$ = .05 (level of significance), $\underline{u}$ = 3 (k-1), $\underline{f}$ = .40 (value for large effect size), and a power of .75. Based upon the specifications used in this study, a table value of $\underline{n}$ = 16 was obtained. Sixteen subjects were randomly assigned to the four treatments conditions (awareness, nonawareness, Five-Step Approach, and control).

Apparatus

An apparatus similar to the one described by Brown and Carr (1989) was used. The key-pressing task consisted of seven switches mounted on a board. The board, 65 cm x 65 cm, was mounted on the frame with the key board lying beneath it, and with the face tilted at 29° toward the subject. Six switches were arranged in a circle (25.4 cm in diameter) around the seventh one, the home key, at the center of the circle. The switches (standard IBM key board switches) had square tops, each side 1.2 cm long, and were labeled with a single digit ranging from 1 to 6. Each switch on the customized key board was soldered to the circuitry of the IBM key board, so that it was slaved to the IBM key board. The distance between adjacent keys on the circle and between the numbered keys and the home key was 12.7 cm. The experiment was controlled by an IBM PS/2, model 80. An illustration of the key-pressing task apparatus is shown in Figure 2.

Tasks

Subjects performed a key-pressing task which required subjects to press eight keys within a goal movement time of 2.5 s. This goal-time was determined based on data obtained from pilot studies. Subjects were able to complete the task within this interval. The sequence of key presses was the 6, 4, 3, 2, 5, 1, 4, 6. This sequence was constant throughout testing and was presented on the screen only during the 10 practice trials.

The second task required subjects to simultaneously perform the key-pressing task while verbally repeating six alphabet letters. The letters were presented on the microcomputer screen for 3 s before the subjects pressed the keys.

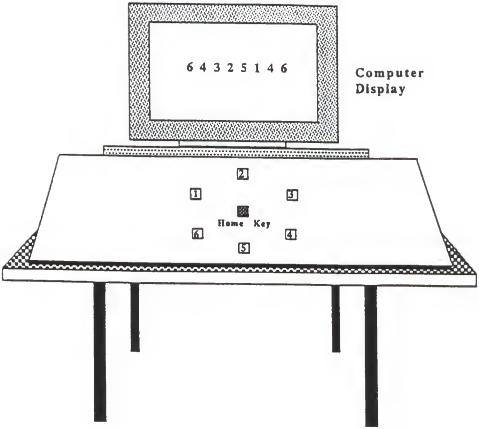

Figure 2. The key-pressing apparatus.

Procedure

Upon arrival to the Motor Behavior Laboratory, subjects completed an informed consent and a demographic questionnaire about background data (as in Experiment 1). Testing took place in a separate room (3 m x 3 m). Task instructions (general and specific) appeared on the screen (except for the specific part of the Five-Step Approach, which were taped on audio cassette). A testing session took about 80 min.

The general instructions informed subjects (in all four groups) how to perform the key-pressing task, and the specific instructions introduced the strategy conditions. It took about 5 min to read the general set of instructions. The specific sets of instructions for the awareness, nonawareness, and control groups were approximately equal in terms of length (number of screens) and number of words. It took about 2.5 min to read the specific directions for the awareness and nonawareness conditions, and about 90 s for the control instructions. The same set of instructions for the Five-Step Approach as used in Experiment 1 was administered. It took about 10 min to listen to it. A complete set of instructions is provided in Appendix G.

Subjects in the awareness group were instructed to be aware of the way that they pressed the keys, to pay attention to specific cues, such as the shape of the keys, and to "feel" the key-pressing movement. The nonawareness subjects were told to focus on a specific cue, such as the center of the screen, to relax, to let the movement flow, and to perform the task as if in a state of automaticity. For the Five-Step Approach, subjects were asked to apply the 5 steps: readying, imaging, focusing, executing, and evaluating during their performance. Subjects in the control group received general instructions about the task, the apparatus, and the Motor Behavior Laboratory.

Before testing began, subjects practiced 10 trials following the testing sequence (6, 4, 3, 2, 5, 1, 4, 6). Before each practice trial, a graphic display of the apparatus and the pattern of the movement sequence (8 numbers), was presented on the screen for about 10 s. Specifically, a red curser drew a line (19.5 cm/s) to each respective key showing the movement paths. When the curser overlapped a previous line (path), it drew in blue. An illustration of the graphical display of the movement pattern is shown in Figure 3.

Two hundred and fifty key-pressing acquisition trials were administered. The graphic display of the sequences of numbers were not presented on the computer screen before the acquisition trials. A trial started when the word 'Ready' appeared in the center of the monitor. Subjects placed their index and middle fingers (held together) of their dominant hand on the home key (center of the circle). After a short delay (either 1, 2, or 3 s), determined randomly, 'Ready' was replaced by the word 'Go'. The subjects pressed the home key of the circle as quickly as possible (RT measure) and then pressed the eight keys in the appropriate order within the 2.5 s goal. The computer recorded all the data, including errors in response time (TT) when the movement time exceeded 2.5 s. Trials in which an error occurred were not analyzed; however, they were recorded. Subjects who would make more than a 20% error rate, (of the total trials), would have been replaced (Snodgrass, Levy-Berger, & Haydon, 1985).

After each trial, three lines of knowledge of results were presented on the monitor: (a) the correct order of keys to be pressed, (b) the sequence of keys actively pressed, and (c) TT (time interval between the first key pressed (home key) and the last key pressed). If a response time figure was displayed in red (instead of white), then an error in sequence was made or the movement was longer than 2.5 s. After examining the three lines of information, the subjects initiated (self-pace) the next trial when ready by pressing the center key.

As in Experiment 1, after every 10 trials, a specific strategy reminder (according to groups) appeared on the monitor. A 5-min rest was given to the subjects before starting the second set of 125 trials. During the first break, the shortened form of the Betts' Questionnaire Upon Mental Imagery, (QMI), (Sheehan, 1967) was administered to the subjects. The questionnaire measured and predicted subjects' capacity to evoke images when required. A comparison between the subjects' ability to imagine and their ability to apply cognitive processes such as learning strategies was made based on the data obtained from the QMI. An example of the QMI is provided in Appendix H.

At the end of 250 trials, a 5-min rest was provided. Subjects were asked to leave the testing room and sit in the adjacent conference room. The experimenter stayed with the subjects. As in Experiment 1, the experimenter initiated a conversation with the subjects about their program, classes, and school-work. Upon completion of the rest phase, an additional 50 trials were administered in the dual-task situation. Instructions for the dual-task were presented on the screen. The task required subjects to simultaneously complete the key-pressing task and a verbal task (verbalize six letters presented on the screen).

A dual-task trial started when the word 'Ready' appeared on the computer screen. After a short delay (1 s), a sequence of six letters was shown up in the center of the screen for 3 s. Subjects were asked to memorize the presented sequence. Then, the sequence was replaced by the word 'Go'. The interval time between the presented letters and the initiation of the task was between 100 ms and 2 s, determined randomly across trials. As in the acquisition trials, subjects pressed the home key as quickly as possible

(RT measures) and then pressed the eight keys while verbalizing the sequence of the six letters. Subjects completed the verbal task as accurately as possible within the 2.5 s goal time. The sequences of the 6 letters were randomly changed across trials. However, the sequence of the numbers to be pressed was the same. A list of the 50 presented sequences is provided in Appendix I.

At the end of testing (300 trials), the subjects completed a questionnaire. As in Experiment 1, the questionnaire was used as a strategy check. Subjects in the awareness, nonawareness, and Five-Step Approach groups were asked if they used the suggested strategies during the performance, and to what extent. If the subjects did not use the specific strategies, they were asked to describe what type of strategy they followed. Subjects in the control group were asked to explain how they approached the task, and what strategy they used (if any).

Experimental Design

For the acquisition phase, a 4 x 10 (Groups x Trial Blocks) ANOVA with repeated measures on the second factor was used to analyze each one of the three dependent variables: (a) reaction time (RT), (b) movement time (MT), and (c) total response time (TT). Separate mixed design analyses 4 x 2 (Groups x Trial Blocks) were conducted on the dual-task data. The number of errors for the key-pressing task was analyzed in a one-way ANOVA.

Additionally, a one-way ANOVA was used to analyze (1) the number of errors (for the verbal task) in the dual-task paradigm and (2) the 35 items of the QMI. As in the first experiment, alpha was set at .05 for all statistical analyses.

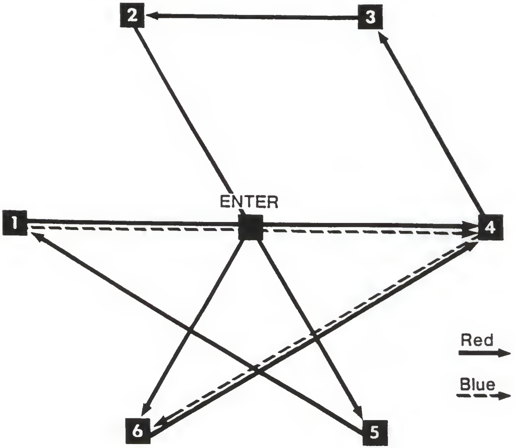

Figure 3. The graphic display during practice.

CHAPTER 4

RESULTS

Experiment 1

Mean absolute constant error (ACE) and variable error (VE) were computed in blocks of 25 trials for all learning strategy conditions, and analyzed separately in mixed design analyses of variance (ANOVAs). Additionally, percentage of errors for the verbal task in the dual-task performance and number of bull's-eyes across 300 trials were analyzed in a one-way ANOVA. Tukey's honestly significant difference (HSD) procedure was used for all follow-up mean comparisons, as appropriate.

The results are presented in relation to the following three considerations: (a) the acquisition phase (ACE, VE), (b) the dual-task performance (ACE, VE, and percentage of errors for the verbal task), and (c) the acquisition and dual-task performance (number of bull's-eyes). Note that the results reported in this study were significant with both the traditional F tests values and the conservative degrees of freedom adjustments (Greenhouse & Geisser, 1959).

Acquisition Phase

Mean throwing data for ACE and VE were analyzed separately in Groups x Days x Trial Blocks (4 x 2 x 5)

ANOVAs with repeated measures on the second and third factors.

Absolute constant error. The analyses revealed two reliable main effects: (a) groups, *F*(3, 68) = 81.00, *p*<.001, *MS*e = 10.01 and (b) trial blocks, *F*(4, 272) = 13.39, *p*<.001, *MS*e = 1.28. The mean group performances for ACE is shown in Figure 4. Tukey's HSD tests indicated that subjects in the awareness group (*M* = 9.63, *SD* = 1.83), the nonawareness group (*M* = 6.75, *SD* = 1.14) and the Five-Step Approach group (*M* = 6.46, *SD* = 1.54) displayed less ACE than subjects in the control group (*M* = 10.75, *SD* = 1.52). Also, subjects in the Five-Step Approach and nonawareness groups were more accurate than subjects in the awareness group.

Additionally, the follow-up tests revealed higher accuracy for trial block 5 (*M* = 8.09, *SD* = 1.59) in comparison to trial block 1 (*M* = 8.95, *SD* = 1.45). No other reliable effects were found.

Variable error. The VE analysis revealed three significant main effects: (a) groups, *F*(3, 68) = 56.61, *p*<.001, *MS*e = 2.21, (b) days, *F*(1, 68) = 7.67, *p*<.01, *MS*e = .90, and (c) trial blocks, *F*(4, 272) = 7.17, *p*<.001, *MS*e = .58. The mean group performances for VE is shown in Figure 5. Tukey's HSD procedure revealed that subjects in the nonawareness group (*M* = 4.37, *SD* = .53) and the Five-Step Approach group (*M* = 4.33, *SD* = .46) were more consistent than the control group subjects (*M* = 5.96, *SD* = .73). No differences were found for the awareness group (M = 5.58, SD = .73), indicating that the awareness strategy did not help to increase ball-throwing consistency.

On the second day (M = 4.96, SD = .71) the ball-throwing task was performed better than the first day (M = 5.16, SD = .49). In addition, performance during trial block 5 (M = 4.95, SD = .88) was better than at trial block 1 (M = 5.32, SD = .83).

Dual-Task Performance: Ball-Throwing and Verbal Report

During the last 50 trials subjects simultaneously performed two tasks: ball throwing and verbal report. Two Groups x Trial Blocks ANOVAs with repeated measures on trial blocks were separately used to analyze ACE and VE. In addition, a one-way ANOVA was conducted to analyze the number of errors for the verbal task.

Absolute constant error. The 4 x 2 ANOVA indicated a reliable groups effect, $F(3, 68) = 32.34$, $p<.001$, MSe = 3.54. Tukey's HSD procedure revealed that subjects in the nonawareness group (M = 6.17, SD = 1.54) and the Five-Step Approach group (M = 6.14, SD = 1.37) performed better than subjects in the awareness group (M = 8.57, SD = 1.70) and the control group (M = 9.70, SD = 1.56). No other significant differences were found.

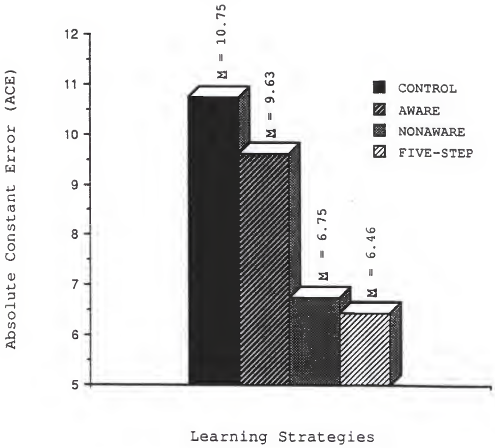

Figure 4. Mean group performances for ACE.

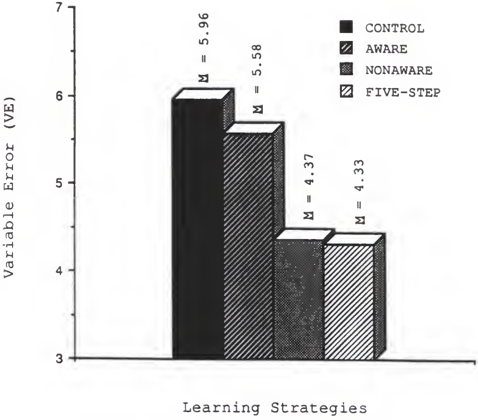

Figure 5. Mean group performances for VE.

Variable error. The analysis revealed a groups main effect, $F(3, 68) = 15.38$, $p<.001$, $MSe = 1.57$. The follow-up analysis showed that subjects in the nonawareness group (M = 4.51, SD = 1.20) and the Five-Step Approach group (M = 4.51, SD = .89) performed significantly better than the awareness (M = 5.37, SD = .86) and the control (M = 6.04, SD = 1.04) subjects. The analysis did not reveal any other reliable effects.

Percentage of errors on the verbal task. A one-way analysis of variance failed to reveal a groups effect, $F(3, 68) = .63$, $p>.05$.

Acquisition and Dual-Task Performance: Number of Bull's-eyes

Further analysis of the throwing performance was conducted on the number of bull's-eyes (when the ball hit the center of the target). The one-way ANOVA revealed a groups main effect, $F(3, 68) = 7.88$, $p<.001$, $MSe = 658.38$ as shown in Figure 6. The follow-up tests indicated that subjects in the Five-Step Approach (M = 25.80, SD = 9.24) hit the center of the target more times than the awareness group (M = 15.44, SD = 8.46) and the control group (M = 12.00, SD = 9.09) subjects. In addition, subjects in the nonawareness group (M = 20.38, SD = 9.56) scored more bull's-eyes than the subjects in the control group. No significant differences between the nonawareness and the Five-Step Approach groups, and between the awareness and control group were found.

Strategy Check

Results of the postexperiment strategy questionnaire indicated that 85% of their respective learning strategy subjects used the strategies during the ball-throwing performance. More specifically, 87% of the awareness subjects, 81% of the nonawareness subjects, and 87% of the Five-Step Approach subjects applied the learning strategies.

Fifty-six percent of the control subjects reported that they developed their own strategies during the performance. Thirty-eight percent of these subjects indicated that they focused attention on the center of the target (the bull's-eye black spot) or on one of the white lines marked on the floor.

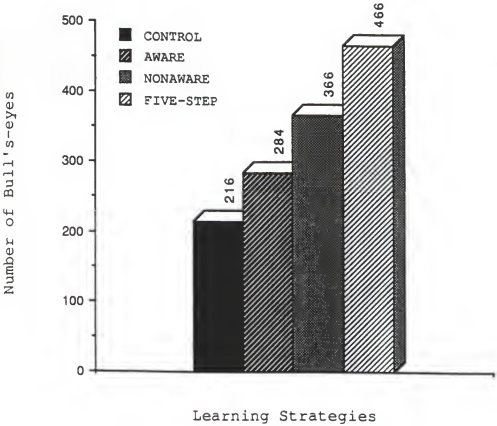

Figure 6. Number of bull's-eyes for the acquisition and dual-task situations.

Experiment 2

To determine key pressing speed and accuracy performances, three dependent variables were recorded (a) response time (TT), (b) movement time (MT), and (c) reaction time (RT). Mean performance blocks of 25 trials were computed and analyzed in mixed design ANOVAs. In addition, the number of errors for the key-pressing task, the number of errors for the verbal task in the dual-task performance, and the items in the QMI were analyzed in a one-way ANOVA. As in Experiment 1, Tukey's HSD procedure was used for all follow-up mean comparisons.

Acquisition Phase

Mean performance across the 250 acquisition trials were calculated for 10 blocks. Three separate 4 x 10 (Groups x Trial Blocks) ANOVAs with repeated measures on the last factor were used to analyze TT, MT, and RT.

Response time. The two-way ANOVA revealed three significant findings: (a) groups, $F(3, 60) = 36.22$, $p<.001$, (b) trial blocks, $F(9, 540) = 19.71$, $p<.001$, and (c) Trial Blocks x Groups interaction, $F(27, 540) = 2.48$, $p<.001$, $MSe = 19540.59$. The interaction is shown in Figure 7. As revealed by Tukey's HSD tests the Five-Step Approach subjects performed faster ($M = 1486.24$ ms, $SD = 145.59$) than the control ($M = 1970.94$ ms, $SD = 203.01$) and the awareness subjects ($M = 1805.75$ ms, $SD = 208.79$) across the 10 acquisition blocks, and better than the nonawareness subjects ($\underline{M}$ = 1670 ms, $\underline{SD}$ = 174.37) in 8 trial blocks (2, 3, 4, 5, 6, 7, 8, and 9). The nonawareness group performed better than the awareness group in trial blocks 1, 2, 4, 5, and 10. The awareness group was better than the control group in all acquisition blocks except the last one.

Movement time. The two factor ANOVA identified two reliable main effects: (a) groups, $\underline{F}(3, 60) = 49.08$, $\underline{p}<.001$ and (b) trial blocks, $\underline{F}(9, 540) = 32.96$, $\underline{p}<.001$. The analysis also revealed a significant Trial Blocks x Groups interaction, $\underline{F}(27, 540)= 4.09$, $\underline{p}<.001$, $\underline{MS}e$ = 11801.14 (see Figure 8). The follow-up procedure indicated that the Five-Step Approach group ($\underline{M}$ = 1222.08, $\underline{SD}$ = 127.61) performed faster than the control group ($\underline{M}$ = 1701.66, $\underline{SD}$ = 164.66), and the awareness group ($\underline{M}$ = 1495.24, $\underline{SD}$ = 149.6) in each of the 10 acquisition blocks, and the nonawareness group ($\underline{M}$ = 1420.23, $\underline{SD}$ = 160.87) in all of the trial blocks 2 through 9. Additionally, the nonawareness group performed better than the awareness group in trial blocks 1, 2, and 10, and the awareness group performed better than the control group in all of the acquisition blocks.

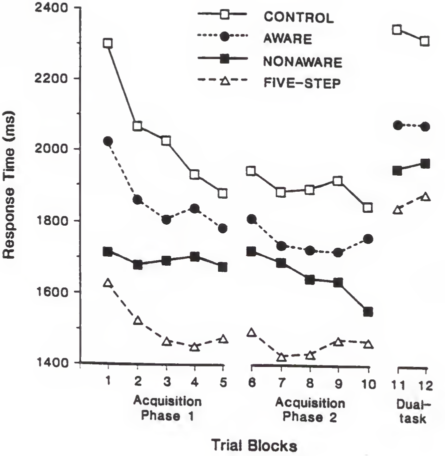

Figure 7. Mean response times for acquisition and for dual-task performance as a function of trial blocks.

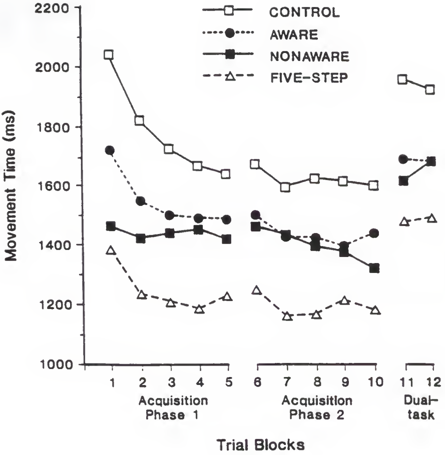

Figure 8. Mean movement times for acquisition and for dual-task performance as a function of trial blocks.

Reaction time. The 4 x 10 ANOVA revealed only a significant trial blocks main effect, $F(9, 540) = 4.69$, $p<.001$, $MSe = 766.63$. Performance on trial block 8 ($M = 264.45$, $SD = 45.98$) was faster than on trial blocks 1, 2, 3, 5, 6, 7, and 9. Additionally, performance in trial block 10 ($M = 266.51$, $SD = 53.80$) was better than at trial blocks 1, 2, 3, 5, 6, and 9.

Number of errors. A one-way analysis of variance did not reveal a groups effect, $F(3, 60) = 1.05$, $p>.05$.

Dual-Task Performance: Key-Pressing and Verbal Report

Three separate 4 x 2 (Groups x Trial Blocks) ANOVAs with repeated measures on the second factor were conducted on TT, MT, and RT. In addition, a one-way ANOVA was used to analyze the number of errors for the key-pressing task and the number of errors for the verbal task.

Response time. Analysis of TT indicated a groups main effect, $F(3, 60) = 6.33$, $p<.001$, $MSe = 209140.3$. Tukey's HSD tests revealed that the Five-Step Approach group ($M = 1860.96$, $SD = 289.51$) performed better than the control group ($M = 2333.37$, $SD = 328.30$). However, no significant differences were revealed among the Five-Step Approach group, the awareness group ($M = 2079.12$, $SD = 288.20$), and the nonawareness group ($M = 1962.71$, $SD = 407.22$). Neither the trial blocks main effect nor the two-way interaction were significant.

Movement time. The ANOVA revealed a groups main effect, F(3, 60) = 7.31, p<.001, MSe = 154510.8. As indicated by Tukey's HSD procedure, only the Five-Step Approach group (M = 1484.4, SD = 203.28) showed faster MT than the control group (M = 1938.98, SD = 270.54). No significant differences were found among the other groups, awareness, M= 1686.40, SD = 215.22 and nonawareness, M = 1649.59, SD = 400.70.

Reaction time. Two main effects were reliable: (a) groups, F(3, 60) = 7.29, p<.001, MSe = 11751.95 and (b) trial blocks, F(1, 60) = 4.45, p<.05, MSe = 1369.26. Tukey's HSD tests indicated that the nonawareness group (M = 350.28, SD = 71.94) performed better than the control group (M = 469.05, SD = 67.77), the awareness group (M = 393.81, SD = 91.09), and the Five-Step Approach group (M = 373.21, SD = 89.11). However, no significant differences were found among the control, the awareness, and the Five-Step Approach groups. In addition, performance in trial block 2 (M = 389.84, SD = 78.56) was better than at trial block 1 (M = 403.64, SD = 81.39).

Number of errors. A one-way ANOVA revealed a groups effect, F(3, 60) = 3.61, p<.05, MSe = 16.84. Tukey's HSD procedure identified that the nonawareness group (M = 3.37, SD = 2.36 showed less errors than the control (M = 7.62, SD = 5.24), and the Five-Step Approach groups (M = 7.18, SD = 3.67). No other differences were found between the awareness subjects and the nonawareness subjects.

Verbal task: number of errors. A one-way ANOVA revealed no significant differences among the four groups.

Acquisition and Dual-Task Performance: Further Analysis on Response Time (TT)

An additional analysis 4 x 2 x 2 (Groups x Learning Situations x Trial Blocks) ANOVA with repeated measures on the second and third factors was conducted. Further analyses on the effectiveness of the three learning strategies on the last two blocks of the acquisition phase (trial blocks 9 and 10) and on the two blocks of the dual-task performance (trial blocks 11 and 12) were calculated.

Mean TT analysis showed two main effects: (a) learning situations, *F*(1, 60) = 101.09, $p<.001$, *MS*e = 94986.68 and (b) groups, *F*(3, 60) = 12.19, $p<.001$, *MS*e = 189566.52. The follow-up procedure revealed that subjects in the Five-Step Approach group (*M* = 1665.37, *SD* = 242.38) and in the nonawareness group (*M* = 1779.35, *SD* = 294.85) performed faster than the control subjects (*M* = 2108.39, *SD* = 290.66). In addition, performance during the last two blocks of the acquisition phase (*M* = 1671.71, *SD* = 208.41) was better than the dual-task blocks (*M* = 2059.04, *SD* = 328.44). No other reliable effects were identified.

The QMI

The one-way ANOVA revealed a groups main effect, *F*(3, 60) = 2.89, $p<.05$, *MS*e = 698.0. Tukey's HSD procedure indicated that subjects in the control group (*M* = 65.56, *SD* = 20.3) were able to imagine the 35 items in the questionnaire better than the nonawareness group (M = 91.87, SD = 33.20). However, no significant differences were found among the other groups (awareness, nonawareness or Five-Step Approach).

Strategy Check

Results of the postexperiment questionnaire revealed that 81% of the learning strategy subjects used their respective strategies during the key-pressing performance. More specifically, 87% of the awareness subjects, 75% of the nonawareness subjects, and 81% of the Five-Step Approach subjects applied the strategies throughout the experiment.

Fifty percent of the control subjects reported that they developed strategies during the pressing performance. Forty-four percent of these subjects focused attention on the center of the screen, and 33% of them reported that they repeated to themselves the eight numbers of the sequence during the experiment.

CHAPTER 5

DISCUSSION, SUMMARY, CONCLUSIONS, AND IMPLICATIONS FOR FUTURE RESEARCH

Discussion

The primary objective in this study was to compare the effectiveness of three learning strategies and a control condition (no strategy) on the learning and performance of two different self-paced motor tasks, ball-throwing and key-pressing. Additionally, an attempt was made to study the influence of these learning strategies on dual-task performance (the ball-throwing task and a verbal task, or the key-pressing task and a verbal task).

Similar results were revealed in Experiments 1 and 2. Learning strategies facilitated motor performance in the acquisition phase as well as in the dual-task performance situation. Subjects using the awareness, nonawareness, and Five-Step Approach strategies performed better, according to various dependent measures, than those who were not taught to use any strategy. In general, the five hypotheses stated in this investigation have been supported or partially supported by the data.

The discussion is organized and presented in relation to the following considerations. The first section includes an analysis on the acquisition phase for the ball-throwing and the key-pressing tasks. In the second section, the dual-task performance situation for both tasks is described. A general discussion on both experiments is presented in the third and last section.

Acquisition Phase

Although the two tasks that were administered in this investigation were self-paced in nature, they represented two very different learning situations. Interestingly, similar results were found for most of the dependent variables used in Experiments 1 and 2.

Ball-throwing task. The first hypothesis predicted that subjects using the learning strategies would achieve better than the control subjects. The data analysis for ACE supported this hypothesis, while the VE analysis provided partial support. Subjects using the awareness, nonawareness, and Five-Step Approach strategies were more accurate than subjects who were not guided to follow a particular strategy. Additionally, subjects in the nonawareness and Five-Step Approach conditions were more consistent as well as accurate in hitting the center of the target than the control subjects.

These findings demonstrated that various learning strategies can enhance the learning and performance of a motor skill. These results are consistent with previous "more laboratory pure" and applied investigations in motor learning research as well as practical work in sport psychology in which the following areas have been examined (a) the influence of the Five-Step Approach on the accuracy of similar throwing tasks (Singer, Flora, & Abourezk, 1989a; Singer & Suwanthada, 1986), (b) the effectiveness of instructional programs in which an emphasis has been made on an awareness state of what learners need to do before and during execution (Cox, 1933; Parker & Fleishman, 1961; Ravizza, 1986), and (c) the mental state realized by skilled performers when they perform at their best (Garfield & Bennett, 1985; Loehr, 1990; Schneider & Fisk, 1983). Furthermore, these findings also confirmed past evidence that has emerged from educational psychology research in which cognitive tasks have been enhanced by the use of particular learning strategies (Garner, 1990; Weinstein & Mayer, 1986).

The data analyses supported the second hypothesis, but not the third one. The second hypothesis predicted that the nonawareness subjects would achieve better than those in the awareness group. The third hypothesis predicted that the subjects using the Five-Step Approach would outperform the awareness and nonawareness subjects. The nonawareness and Five-Step Approach groups displayed less ACE than the awareness group. In addition, the Five-Step Approach subjects were able to hit the bull's-eye area more times than subjects in the awareness group. However, the three learning strategies were the same in assisting subjects to improve their performance consistency. Additionally, the data analysis revealed no significant differences between the nonawareness and the Five-Step Approach groups in accuracy and consistency of throwing performance. These findings indicate that both strategies were equally effective.

Although the awareness subjects improved their throwing accuracy, they did not attain the level achieved by the nonawareness and Five-Step Approach subjects. Moreover, the awareness strategy did not help to facilitate ball-throwing consistency. Neither the linear trend analysis for ACE nor for VE were significant. That is, the accuracy and the consistency of the throwing task were not improved gradually during acquisition. Additionally, subjects using the awareness directions could not hit the center of the target more times than the control subjects.

An explanation of these findings may be related to the structure and nature of the awareness strategy. Basically, these subjects were given task instructions and guidance on how to use environmental and situational cues to control their movements (e.g., to listen to the noise generated by the targetboard after each throw, or to pay attention to their throwing motion). On the one hand, this additional information helped them to achieve better than subjects in the control condition, as has been pointed out in early investigations on instructional programs (e.g., Cox, 1933;

Davies, 1945). On the other hand, by using this proprioceptive information, subjects in the awareness group were required to divide their attention among several cues, and perhaps they could not (a) progressively improve their throwing skills or (b) attain a high level of performance (Shiffrin & Dumais, 1981; Treisman, 1969).

An emphasis on an 'automatic mode' during execution was made in the nonawareness strategy and in the fourth step of the Five-Step Approach. Subjects were directed to execute without thinking of the act or the outcome. Although the Five-Step Approach contains awareness as well as nonawareness components, it appears that by mainly stressing the nonawareness part of it, as has been done in the nonawareness strategy, performance can be efficiently enhanced. From a practical point of view, instead of spending equal time on the readiness stages (e.g., readying and imaging steps), instructors might allocate more time on explaining to beginners what to do during execution.

In terms of directing individuals what to think about during the actual performance, the superiority of the nonawareness and the Five-Step Approach orientations confirmed past practical reports (Gallwey, 1985; Garfield & Bennett, 1985; Singleton, 1988) as well as scientific investigations (Schneider & Fisk, 1983). Subjects who executed without involving thought processes, and tried "just to do it," attained a higher level of skill. Since the nonawareness strategy or the fourth step of the Five-Step Approach reflect behaviors of skilled performers, then beginners should also try to focus exclusively on a target cue and execute with a quiet mind.

In the control condition, subjects learned how to improve the accuracy of their performance without any guidance as to what strategies to use. The linear trend analysis was significant for the ACE curve; however, it was not for the VE curve. There are two reasons for observing improvement in this condition. First, practice alone should facilitate performance (Schneider, 1985; Singer, 1980a), as long as it is reasonably directed. Second, the postexperiment questionnaire revealed that a number of subjects (about 56% of the control subjects) spontaneously generated their own strategies (e.g., focusing attention) throughout execution. These findings confirmed the notion that when learners know how to develop their own strategies and use them effectively, then improvement in performance can be seen although formal strategy instruction is not given (Garner, 1990).

Only the nonawareness and the Five-Step Approach enhanced ball-throwing consistency. In other words, neither the awareness instruction nor practice alone (control condition) facilitated VE performance. It might be speculated that it is more difficult and it takes more time to improve consistency than accuracy of a throwing task.

Although skilled piano players or gymnasts need a long period of time, e.g., weeks, months, and years, to improve both high-level accuracy and consistency performances (Bloom, 1986), beginning learners may complete less complex tasks quite accurately at an early stage of learning. Perhaps, they are highly motivated to meet a new challenge or they may do well merely by chance (Kerr, 1982). To enhance consistency, individuals should not only practice the mechanics of the movements. They need to learn how to focus attention on a specific cue as well as how to block potential distractors during repeated executions of an act (Orlick, 1990). Obviously, both the awareness and control groups were not guided to do so.

The Groups x Trial Blocks interaction was not significant. This indicates that the same pattern of skill acquisition existed among all the groups.

Key-pressing task. The data analyses supported hypotheses one and two, as was reported with the ball-throwing performance. However, with the key-pressing task, support for the third hypothesis was also obtained. The three learning strategy groups showed the fastest MT and TT in comparison with the control condition. These results are consistent with past investigations in which the effect of the Five-Step Approach on a similar pressing task has been examined (Singer, DeFrancesco, & Randall, 1989; Singer, Flora, & Abourezk, 1989a, 1989b).

The significant Groups x Trial Blocks interaction further supports the effectiveness of the learning strategies. Subjects in the awareness, nonawareness, and Five-Step Approach conditions achieved better than the control subjects in all 10 acquisition blocks. Also, the nonawareness and the Five-Step Approach subjects performed better than subjects in the awareness group. The Five-Step Approach subjects outperformed the nonawareness subjects in 8 trial blocks.

Subjects using the Five-Step Approach, although demonstrating the best performance across the 10 acquisition blocks, did not consistently improve their performance. The linear trend analysis for the Five-Step Approach curve was not significant; however, it revealed a strong trend ($p = .052$). The effect of the strategy was extremely strong at an early stage of learning. For example, the mean TT scores for trial block 3 was 1467 ms. In comparison, the mean TT scores for trial block 9 was 1432 ms. In other words, the improvement was only 35 ms.

Two explanations are offered to describe these findings. First, subjects may have approached a floor effect (Schmidt, 1988) in that they had little possibility of improving upon their attained best performance. This and related learning and performance effects that describe fluctuations in a learning curve, such as a ceiling effect, were not found in past investigations. For example, in

Singer and Suwanthada's (1986) study, subjects completed throwing and shooting tasks. A ceiling effect was not found; that is, subjects who used the Five-Step Approach progressively improved their throwing and shooting performances throughout the block of trials.

It is possible, however, that the nature of a task, such as the pressing task used in this study, combined with the immediate effect of the strategy, inhibited any further improvement. Although subjects were told that they could complete the pressing task in 2.5 s, the Five-Step Approach subjects managed to do it in 1.5 s during the first three trial blocks of the acquisition phase. Perhaps, the time-restriction of the task and the productive use of the strategy in early stage inhibited any further improvement in late phases of acquisition.

Second, subjects in the Five-Step Approach group apparently attained a state of automaticity in their pressing performance. The simple main effect analysis indicated that no significant differences in the TT scores existed between trial blocks 2, 3, 4, 5, 6, 7, 8, 9, and 10. In other words, subjects using the Five-Step Approach achieved the same level of proficiency across 9 of the acquisition blocks. It should be emphasized that this was the best performance among the groups that was demonstrated during the acquisition stage. Evidently, this performance met a basic criterion of an automatic process; that is, the task is performed fast without increasing the number of errors (Logan, 1988a, 1988b, 1990; MacKay, 1982).

Even though no distinct criteria of what requirements should be met for subjects to attain automatic performance were established in the present study as well as in previous investigations dealing with automatization (e.g., Brown & Carr, 1989; Logan, 1990), it is possible that subjects in the Five-Step Approach group attained a high level of performance associated with automaticity. The 2.5 s TT goal was determined based on a pilot study, and it reflected the mean TT performances across all four conditions. If the Five-Step Approach subjects reduced 1 s from their TT scores as well as succeeded to maintain this achievement throughout 9 trial blocks, it appears that automatic processes may have been activated.

Further evidence for the high level of proficiency associated with automaticity that was demonstrated by the Five-Step Approach group came from the bull's-eye data analysis: The Five-Step Approach group also performed their best. In other words, these subjects achieved the absolute score (a "1" score in this investigation) more times than the awareness and control groups. Obviously, the bull's-eye score is the optimal performance that can be attained in many throwing activities (e.g., a dart-throwing).

Similar findings were found in the simple main effect analysis for the nonawareness learning curve. There were no significant differences among trial blocks 2, 3, 4, 5, 6, 7, 8, and 9 in the TT performances. However, it may be speculated that a state of automaticity was not attained in this case because more room for improvement was left (e.g., the difference of TT scores in some of the trial blocks between the nonawareness and the Five-Step Approach subjects was about 175 ms).

There are advantages and disadvantages for observing an immediate enhancement in skill acquisition. One advantage is that a high level of skill can be achieved in a relatively short period of time. The disadvantage is that learners may not be motivated enough to continue their progress and reach a higher level of proficiency (Good & Brophy, 1990). In terms of strategy use, immediate improvement can be very beneficial for learners as well as for educators. If one task is improved quickly, then other tasks can be introduced without delay. Moreover, more time may be allocated to develop other essential aspects of an overall task (for example, playing tennis), such as skills or processes of detecting and reducing mechanical errors (e.g., a serve was too short) or cognitive errors (e.g., a wrong tactical decision was made) (Adams, 1971; Senders & Moray, 1991). Additionally, such cognitive strategies as imagery (Feltz & Landers, 1983) and attentional focus (Nideffer, 1986; Singer, Cauraugh, Murphey, Chen, & Lidor, 1991) may be improved.

As with the ball-throwing task, subjects in the control condition learned how to improve the task without any strategy directions. The linear trend analysis for the TT scores was significant, indicating that performance was gradually improved. This may be explained by the observation that 50% of the control subjects developed their own strategies, such as focusing attention and self-talk, as was identified by the postexperiment questionnaire analysis.

Considering the QMI data analysis, the control subjects were able to imagine the 35 items in the questionnaire better than the subjects in the nonawareness condition. The possibility that these subjects had a better ability to evoke images when required did not help them to attain the level achieved by the strategy subjects. If individuals have the capability to activate cognitive processes, but do not know how to use them, or are not guided appropriately how to apply them, they may not attain a level of improvement demonstrated by individuals who are guided in the use of a strategy (Garner, 1990; Peverly, 1991).

The RT scores associated with the key-pressing performance were not enhanced by using any of the learning strategies. In this type of strategy research, other motor learning and educational psychology investigations have not studied the effect of learning strategies on this dependent variable. In contrast, in some studies, an attempt was made to examine the relationship of a learning strategy, such as the Five-Step Approach, with preparation time (PT) (Singer, DeFrancesco, & Randall, 1989; Singer, Flora, & Abourezk, 1989a).

The PT interval in these experiments was defined as the duration of time from the illumination of a starting signal to the self-initiation of the movement (when ready to move) (e.g., the first microswitch released) (Singer, Flora, & Abourezk, 1989a). Although this definition is similar in its orientation to an RT measure, two modifications were made in Singer, Flora, and Abourezk's (1989a) study to discriminate it from a standard RT measure. First, subjects were told that they could take time to apply the readiness steps before initiating the task. In other words, they were not guided to try to respond to the stimulus as quickly as possible. Second, there was no time limit during this period, as the subjects were allowed to initiate activity when ready. Longer PT was observed to be associated with shorter MT (Singer, Flora, & Abourezk, 1989a).

This finding and the two modifications that were made in Singer, Flora, and Abourezk's (1989a) study may explain the lack of improvement in RT performance in the current investigation. It should be noted that subjects in the current investigation were guided to respond to the stimulus (the 'Go' signal) as quickly as possible. To stimulate thoughts about planning ahead, as in the awareness strategy or the Five-Step Approach, subjects may need some time before the actual execution. For example, in a basketball game, the free-throw shooter officially has 10 s to shoot the ball after it is given to him or her by the referee. Maximal personal readiness time should be taken before the shot is executed.

It is interesting to examine the relationship between speed and number of errors in the key-pressing performance. While subjects in the learning strategy groups performed faster than the no strategy subjects, no significant differences were noted in the number of errors made among the groups. Each one of the groups demonstrated a similar rate of errors: a 12% rate for the control, a 14% rate for the awareness, a 15% rate for the nonawareness, and a 13% rate for the Five-Step Approach subjects. Moreover, none of the subjects exceeded the 20% error rate, initially determined for controlling the validity of the collected data; consequently, none of them was replaced.

According to Fitts (1954) and Pachella (1974), the group with the fastest MT or RT would produce the most errors. This apparently was not the case in this study. Although the learning strategies did not help the subjects to reduce the rate of errors in comparison with the control subjects, they did reduce the MT scores without increasing the error rate.

The superiority of the learning strategies in the ball-throwing performance as well as the key-pressing performance provided support for the fourth hypothesis stated in this investigation. Hypothesis four predicted that skill realized in both the ball-throwing task and the key-pressing task would be facilitated through the use of the three learning strategies. It was found that performance in both tasks was enhanced.

These findings, although obtained from two different samples, confirmed the idea that an effective strategy can be useful across different but related tasks (Derry & Murphy, 1986; Singer, 1988; Wittrock, 1986). In terms of practical implications for strategy use, individuals may (a) save time and effort by being able to modify the same strategy to different learning situations and (b) be able to perform better in the new learning environment.

Although performances of both tasks were enhanced by the use of all three strategies, it is preferable to use the nonawareness strategy or the Five-Step Approach because both (a) demonstrated the best ball-throwing and key-pressing performances and (b) emphasized the same mode during execution; that is, individuals should preplan the act, focus on a specific cue, and "just do it." Because the Five-Step Approach has already been established as a useful technique in enhancing primary self-paced motor tasks as well as transfer tasks that are performed by the same subjects (e.g., Singer, DeFrancesco, & Randall, 1989), it appears that also the nonawareness strategy may be effectively used across different but related self-paced motor tasks as well.

Furthermore, because both strategies facilitated achievement in two different but related self-paced motor tasks, perhaps both strategies could enhance success in transfer situations. Transfer in two tasks depends on the similarity between the two (e.g., they are self-paced in nature) (Anderson, 1987). However, expectancies for transfer are usually small (Schmidt, 1988). To increase success with transfer situations, learners need to retrieve previous knowledge to a somewhat new learning environment as well as to apply past experiences to a new but similar task. An effective learning strategy (e.g., the Five-Step Approach) should assist individuals to achieve better under these conditions (Derry & Murphy, 1986; Singer, 1988).

Dual-Task Performance

The primary task was the one that was used during acquisition (ball-throwing or key-pressing), and a verbal task served as the secondary task. The results for the primary task were in line with those found in the acquisition analyses. However, this was not the case with the secondary task. The learning strategies did not facilitate performance in the verbal task used in each experiment.

The ball-throwing task and the verbal task. The fifth hypothesis predicted that while performing the ball-throwing task and the verbal task simultaneously, subjects using learning strategies would demonstrate a higher level of skill in the primary task than subjects in the control group. The ACE and VE analyses partially supported this hypothesis. Subjects in the nonawareness, and Five-Step Approach conditions were more accurate and consistent in performing the primary task than subjects in the control condition. As has been pointed out in the discussion on the acquisition phase, the nonawareness and the Five-Step Approach subjects achieved better than the awareness subjects.

The nonawareness and Five-Step Approach subjects attained the highest level of skill during acquisition. They also succeeded in maintaining a high level of achievement during the dual-task performance situation. These findings were predicted and could be explained by the possibility that these subjects attained a state of proficiency associated with automaticity with the throwing task throughout of the acquisition practice. When asked to simultaneously execute with another task, they still managed to maintain a high level of performance in the primary task.

The trial blocks main effects in the ACE and VE analyses were not significant. Subjects did not improve the primary task performance from the first block to the second in the dual-task situation. These findings do not support past investigations in which practice has been shown to enhance concurrent performance (Brown & Carr, 1989; Shaffer, 1975; Spelke, Hirst, & Neisser, 1976).

The lack of improvement in the dual-task situation may be explained by the possibility that while completing 250 acquisition trials, the subjects seemed to master the primary skill; consequently, not much room was left for further improvement. In previous motor learning investigations in which the influence of different strategies on achievement in a similar throwing task was studied, a lesser amount of trials; e.g., 40, has been suggested as sufficient practice to master a throwing skill (Kirschenbaum, Wittrock, Smith, & Monson, 1984).

Moreover, the trial blocks main effects in the further ACE and VE analyses of the last trial block of acquisition in Day 2 and the two dual-task trial blocks were not significant. Both accuracy and consistency in ball-throwing performance were not hindered when the secondary task was introduced. Although subjects completed the throwing task in a more demanding learning situation, they maintained a high level of throwing skill. In the motor learning literature, it is well known that when an individual demonstrates a high level of proficiency under a "real-life situation", such as a game or a contest, skill mastery has been already achieved (Kerr, 1982; Singer, 1982).

The analysis of data in the secondary task performance revealed no significant difference in percentage of errors for the verbal task among the four learning conditions. More specifically, the error rate was relatively low for each one of the groups: a 14% rate for the control, a 16% rate for the awareness, a 12% rate for the nonawareness, and a 16% rate for the Five-Step Approach. These findings indicated that (a) the learning strategies did not help to perform the secondary task better and (b) the secondary task appeared to be relatively easy to complete. The fact that the control subjects completed the secondary task in a similar way as the strategy subjects indicated that the task was probably not challenging enough.

Since this is the first study in which the influence of learning strategies on concurrent task performance has been conducted, it is impossible to compare the present findings with previous ones. Therefore, the discussion of these findings that follow should be helpful in future related research.

The key-pressing task and the verbal task. The data analysis partially supported the fifth hypothesis. Only the nonawareness and Five-Step Approach strategies enhanced performance. The Five-Step Approach subjects maintained the highest level of skill by demonstrating the fastest MT and TT scores in comparison to the control condition. The nonawareness subjects demonstrated the fastest RT scores in comparison to subjects in the control, awareness, and Five-Step Approach groups.

Two observations can be made with regard to these findings. First, the two strategies in which an emphasis was made on executing without involving active thought processes lead to the best performance. Second, during acquisition, none of the strategies enhanced RT. However, under dual-task conditions, the nonawareness strategy helped to improve RT.

It appears that the nature of the strategies played an important role in influencing TT, MT, and RT performances, as has been found for the Five-Step Approach by Singer, DeFrancesco, and Randall (1989). This strategy did not lead to the fastest RT because some time was needed to apply the readiness steps before initiating the task. Although the Five-Step Approach group was guided to execute without involving any thought processes, apparently prior to the initiation of the task, some time was taken by the subjects to activate cognitive processes that were related to the readying and imaging steps. However, when they were ready to undertake movement, these subjects achieved the highest MT and TT levels, as has been reported in a previous study (Singer, Flora, & Abourezk, 1989a).

In contrast, the nonawareness subjects "just did it". They were not required to process any information before initiating the task; therefore, they were able to respond the fastest to the presented stimulus. By preplanning the action and focusing only on one specific cue (e.g., the center of the screen), the nonawareness subjects apparently learned to block out any internal or external distractors. This approach has been suggested by sport psychologists as an essential aspect of almost any training program for athletes to attain a high level of performance (Orlick, 1990; Weinberg, 1984).

The nonawareness subjects also performed the best in the primary task in terms of number of errors. The analysis of errors indicated only a 6% error rate for the nonawareness subjects in comparison to 15%, 14%, and 15% error rates for the control, awareness, and Five-Step Approach, respectively. Although the nonawareness subjects demonstrated the fastest RT scores, they did not increase in number of errors. These findings are not consistent with previous explanations of speed-accuracy trade-off in motor task performance (Fitts, 1966; Pachella, 1974). Again, these findings may be related to the nature of the strategy combined with a high level of skill that was attained during acquisition.

Further analysis of the TT scores in the last two trial blocks of acquisition and the two dual-task trial blocks indicated that performance in the primary task during the last phase of acquisition was faster than in the dual-task situation. More specifically, it took 900 ms more for the control subjects, 683 ms more for the awareness subjects, 734 ms more for the nonawareness subjects, and 783 ms more for the Five-Step Approach subjects to complete the primary task when the secondary task was introduced. Such findings are in line with past investigations in which a decrement in the primary task was noted while the secondary task was introduced (Navon & Gopher, 1979; Trumbo & Noble, 1970). Although the learning strategy subjects performed better than the no strategy subjects, they could not maintain the same skill level attained in the acquisition phase. In other words, none of the learning strategies assisted subjects in maintaining their final solo task performance in the primary task when the secondary task was introduced.

There are at least two possible explanations for the decrement in the primary task performance as was demonstrated by the strategy subjects in the dual-task situation. First, subjects were not directly instructed how to apply their particular strategy under the dual-task condition. Consequently, they had to modify their strategies to meet the new demands in a new learning/performing situation. This adjustment may have caused a deterioration in the primary task performance.

Second, although the strategy subjects were given useful information on how to execute and about what to think, they needed to divide their attention when the secondary task was introduced. The fact that they performed better than the control subjects provided further support for the effectiveness of the strategies in the primary task performance. However, the new attentional load caused increased slowness in the key-pressing task (Korteling, 1991; Trumbo, 1977).

The analysis of the secondary task indicated that none of the strategies facilitated verbal task performance. The error analysis revealed a 20% error rate for the control subjects, a 18% error rate for the awareness subjects, a 17% error rate for the nonawareness subjects, and a 19% error rate for the Five-Step Approach subjects.

These findings can be explained by the possibility that the secondary task was not sufficiently challenging to perform, as was noted in the dual-task situation in Experiment 1. If individuals are able to memorize between 5 and 9 items for a short period of time (Miller, 1956), a sequence of 6 letters may not be considered a heavy load. It should be remembered that achievement in the primary task was of main interest in the dual-task situation. The secondary task was to serve as a distractor condition. Therefore, the effect of the strategies in a more demanding as well as challenging learning situation was examined.

Additionally, 25% of the subjects who participated in the experiment reported that they used a chunking method to do well in the verbal task, as was indicated in the postexperiment questionnaire. It appears that subjects in the learning strategy conditions used their particular strategies in the primary task performance situation but neglected them in the performance of the secondary one (the verbal task).

Individuals have the ability to spontaneously use a chunking method to do well in cognitive activities, such as memorizing a list of words or reading a paragraph in a text book (Cermack, 1976; Kail, 1984; Newell & Rosenbloom, 1981). As has been pointed out earlier in the discussion, subjects in the current investigation were not directly oriented in the use of the strategies under the dual-task performance situation. Considering the postexperiment results and past evidence about memory use (e.g., Cermack, 1976; Kail, 1984), it is possible that subjects developed a spontaneous chunking technique in attempting to complete the secondary task better in the dual-task situation.

General Discussion

The data from Experiments 1 and 2 confirmed the belief that task-relevant strategies can enhance achievement in learning (Garner, 1990; Peverly, 1991). Moreover, the results supported prior motor learning research and practical work in sport psychology in which (a) simple and complex motor tasks have been enhanced by the use of instructional programs in which an emphasis has been made on an awareness approach to learning and performance (Cox, 1933; Parker & Fleishman, 1961; Ravizza, 1986), (b) laboratory as well as field motor activities have been facilitated by applying a nonawareness type strategy to learning and performance (Garfield & Bennett, 1985; Loehr, 1990; Schneider & Fisk, 1983), and (c) self-paced motor tasks were facilitated by the use of the Five-Step Approach (Singer, DeFrancesco, & Randall, 1989; Singer, Flora, & Abourezk, 1989a, 1989b; Singer & Suwanthada, 1986).

In both experiments, subjects using the learning strategies achieved better than the control subjects. Although none of the strategies resulted in superior accomplishments in all of the dependent variables that were identified in this investigation, the nonawareness and the Five-Step Approach subjects demonstrated the highest level of ball-throwing and key-pressing performances.

The proficiency demonstrated by the nonawareness and Five-Step Approach subjects may demand a reevaluation of traditional instructional programs. Instructors as well as beginning learners should understand how advanced learners control thoughts and behaviors during execution. It appears that beginners can benefit from attempting to use some of the expert's strategies that they apply during execution. Typically, instructors and coaches direct students and players to pay attention to what they are doing and to be aware of their performance (Davies, 1945; Ravizza, 1986). The results from the current investigation, although in agreement with this notion, suggest that learners can achieve even better if they do not involve any thought processes during execution.

In the nonawareness and Five-Step Approach strategies an emphasis has been made on execution without thinking about the act or outcome. Subjects who were directed to perform as if in a state of automaticity and to "let the movements flow" performed more accurately, consistently, and faster than those who were directed to think about what they were doing.

Considering these results, people attempting to master any self-paced activity should receive instructions as to how to think, what to think about, and when to think prior to and during the performance. Learners need to be guided as to what to do with their thought processes. Thus, instructors should direct them how to preplan their action, to block internal thoughts, and to perform the task without paying attention to internal and external details. Basically, they may need to stress the "just do it" approach as has been proposed in the nonawareness strategy and the Five-Step Approach as well as for achievement in sport settings programs (Gallwey, 1981; Garfield & Bennett, 1985; Singleton, 1988).

In fact, instructors should preferably consider teaching either the nonawareness strategy or the Five-Step Approach, depending upon the situational demands and the time available. For example, during a practice session, instructors can direct learners how to use the Five-Step Approach appropriately as a global strategy for learning and performance. More time would be spent on the third and fourth steps of the strategy in which a reflection of what individuals should actually do during execution is stressed. In other words, instructors should emphasize the nonawareness approach to learning and performance. Because both ball-throwing and key-pressing performances were facilitated at a very early stage of learning (e.g., first trial block) under the nonawareness and Five-Step Approach conditions, beginning learners should be encouraged to attempt to use either strategy. Although the Five-Step is a more comprehensive, time-consuming, and complicated technique than the nonawareness approach, both left an immediate impact on the subjects.

In both experiments, the learning strategies did not enhance performance of the secondary task in the dual-task performance situation. Only the primary tasks were performed better by the strategy subjects in comparison to the control condition. It is speculated that (a) the secondary tasks were not challenging enough to perform and (b) subjects may need more than 50 trials to achieve a high level of skill in the primary task as well as the secondary one (Schneider, 1985).

In summary, the data indicate that not only may the Five-Step Approach be considered as a useful technique in enhancing the learning and performance of self-paced motor activities, as has been shown already in the literature.

The nonawareness approach is equally effective. The awareness approach is not quite as influential, but nevertheless better than the a no-strategy learned condition. Novices can successfully use an expert's mental approach, at least for the thought processes used during the execution of the type of self-paced acts administered in this study.

Summary

The general purpose of this investigation was to compare the effectiveness of three learning strategies on achievement in two self-paced motor skills, ball-throwing and key-pressing. More specifically, investigated was the influence of (1) an awareness strategy (to use kinesthetic and environmental cues, to be aware of the task, to feel the motion, and to think about the act), (2) a nonawareness strategy (to preplan the action, to let the movement flow, and to perform the task as if in a state of automaticity), (3) the Singer Five-Step Approach (which includes the stages of readying, imaging, focusing, executing, and evaluating), and (4) no strategy (the control condition).

Two experiments were conducted to resolve the issues raised. A ball-throwing task, sport-type in nature, was administered in the first experiment. In contrast, in the second experiment, a key-pressing laboratory task was completed. The data obtained from the two different learning task situations provided a greater understanding of the influence of the learning strategies on self-paced motor task performances.

In Experiment 1, 72 subjects were randomly assigned to one of the four conditions. They were given 125 ball-throwing trials on Day 1. The task required subjects to throw a paddleball at an archery-type target with their nondominant hand in an overhand motion. During Day 2, subjects completed 125 more trials with the ball-throwing task and 50 trials in a dual-task performance situation. In the dual-task situation, subjects were asked to simultaneously perform the ball-throwing task and to verbalize sequences of 5 one-digit numbers presented by audio cassette. A strategy reminder was given to subjects during the 250 acquisition trials.

In Experiment 2, 64 subjects were randomly assigned to the same four learning strategy conditions. They completed 250 key-pressing trials followed by 50 trials of dual-task performance (the key-pressing task and a verbal task). The pressing task required subjects to press a designated sequence of 8 keys within a goal movement time of 2.5 s. In the dual-task situation, subjects verbalized sequences of 6 letters presented on the computer monitor while pressing the 8 keys. As in Experiment 1, a strategy reminder was given to subjects during the 250 acquisition trials.

Two-factor and three-factor ANOVAs revealed similar results for Experiments 1 and 2. The three learning strategy groups achieved better than the control group (no strategy) in the acquisition phase as well as in the dual-task performance situation. More specifically, the awareness, the nonawareness, and the Five-Step Approach subjects completed the ball-throwing task (Experiment 1) more accurately and consistently, and the key-pressing task (Experiment 2) faster than subjects who were not taught any strategy. Among the three learning strategies, subjects in the Five-Step Approach and the nonawareness groups attained a higher level of skill than the awareness subjects.

In the dual-task situations, the learning strategy groups performed better in the primary task (ball-throwing in Experiment 1 and key-pressing in Experiment 2). However, in Experiment 2, a decrement in the primary task performance was identified when the secondary task was introduced in comparison with performance in the primary task in late phases of acquisition. Additionally, the learning strategies did not facilitate performance in the secondary task (a verbal report). All four groups showed the same amount of error percentages in the verbal task.

The results suggested that learners should learn to use task-pertinent strategies to enhance learning and performance. In addition, beginners can benefit from approaching a situation as skilled performers typically do. That is, by executing a self-paced task (1) as if in a state of automaticity, (2) without thinking about the activity, and (3) without paying attention to details, learners should be able to accomplish at a higher level.

Conclusions

Based on the findings and within the limits of this study, the following conclusions are made:

1. Task-pertinent learning strategies enhance motor task performance.

2. Dual-task performance may be facilitated by using appropriate learning strategies for the learning of the primary task.

3. Among the three learning strategies, subjects in the Five-Step Approach and the nonawareness groups achieved better than the awareness subjects.

4. Novices may learn and perform better when they apply strategies that are apparently used by skilled performers.

Implications for Future Research

On the basis of this study, the following suggestions are offered for future investigations conducted in this area:

1. The effectiveness of the three learning strategies across two different self-paced motor tasks was ascertained in this investigation. However, the two tasks were performed separately by two different samples of subjects. Therefore, the transferability effect of the strategies has not been studied directly. It has been already established

in the literature that an ideal strategy should be appropriately applied by individuals in different but related learning settings (Derry & Murphy, 1986; Singer, 1988). In the motor learning literature, only the influence of the Five-Step Approach on achievement in primary and transfer tasks performed by the same subjects has been investigated (e.g., Singer, DeFrancesco, & Randall, 1989). Future learning strategy research should examine the generalizability effect of the awareness as well as nonawareness strategies across different self-paced motor activities performed by the same individuals.

2. In most learning strategy investigations an attempt has been made to study the influence of a learning strategy (e.g., the Five-Step Approach) on achievement in the early stages of practice. For example, in one study, subjects were given 48 trials with the primary task and then completed 50 trials in a related task (Singer, DeFrancesco, & Randall, 1989). Furthermore, the strategy instruction was administered only in one training session (e.g., Singer & Suwanthada, 1986). It would be interesting to examine (a) the influence of the awareness, nonawareness, and Five-Step Approach strategies on achievement at advance phase of practice, i.e., 1000 or 1500 trials (Logan, 1990; Rabbitt & Banerji, 1989) and (b) the effect of several strategy training sessions on learning and performing motor tasks.

It is expected that by conducting a long-term strategy session combined with extensive practice learners will achieve better and even attain a state of automaticity in motor task performance (Logan, 1988b; MacKay, 1982). Furthermore, such important processes as decision-making, memory use, and the focus of attention should be facilitated by the repetitive use of an effective learning strategy.

3. The results of this study determined that, in the dual-task performance situation, the learning strategies did not help subjects to attain a high level of proficiency in the secondary task. Although the primary tasks in both experiments were of main interest, and the secondary tasks served as a distractor condition, it would be also interesting to study the influence of the strategies on secondary task performance. The reason for this is that individuals very often perform more than one task simultaneously in routine daily life activities as well as in sport events. Hence, further investigation is recommended on the use of particular learning strategies for simultaneous effective performance of a primary task and a secondary task. Perhaps the secondary task should be designed with a more challenging degree of difficulty than was the case in the present study; that is, with more room to improve with practice.

Considering these suggestions for future research, more investigations in motor learning should be conducted to understand what learners need to think about during execution. Good educators, trainers, and coaches seem to know very well how to explain to learners how to perform the tasks of interest and what techniques and tactics should be implemented (Schmidt, 1991; Singer, 1980a). They also know how to evaluate performance and what kind of feedback to provide at the completion of the activity (Magill, 1989). However, do they really know how to guide learners to control their thoughts prior to and during execution? Can they explain to individuals what to think about when they actually undertake the activity? Furthermore, are they able to offer learners useful guidance as to what to do while they are on their own in a future new demanding learning situation?

Although an attempt to provide some answers to these questions has been made in the current investigation, much more strategy research should be undertaken. It has already known that effective learning strategies should help individuals how to prepare themselves to execute as well as how to evaluate their own performance (Garner, 1990; Singer, 1988). However, useful strategies should also assist learners to know what to do as well as what to think about during the actual act. With more research on these and related questions, instructional and training programs should be improved, and learners should be better prepared to use practice time more economically and successfully.

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APPENDIX A
AN INFORMED CONSENT FOR EXPERIMENT 1

University of Florida
Department of Exercise and Sport Sciences
Center for Exercise Science
Informed Consent - Experiment 1

Project Title: Learning Strategies and Automaticity in Skilled Performance.

Principal Investigators: Robert N. Singer, Ph.D., James H. Cauraugh, Ph.D., Ronnie Lidor, Graduate Student, Motor Behavior Laboratory, 25 Florida Gym, 392-0584, ext. 26

This is to certify that I, ____________________________, hereby agree to participate as a volunteer in this scientific investigation as part of an authorized research program at the University of Florida, under the supervision of James H. Cauraugh.

Purpose and Testing Procedures

Prior to testing you will hear some taped and verbal instructions about the motor task to be learned. After the instructions, you will complete five sets of 25 non-dominant hand throws at the target. You should try to throw the ball as close to the center of the 4' diameter target as possible. While executing a throwing motion try to apply the specific directions as you have heard. A computer will automatically record the accuracy of each throw. Another trial will begin in about 5 seconds. A 45 second rest period will be given after each set.

General Information

(a) I understand that the principal investigator will answer any of my questions about the research project and my rights as a volunteer subject.

(b) I understand that there is minimal risk to my health and well being.

(c) I understand that I will not receive any money for my participation in this study.

(d) I understand that I am free to withdraw my consent and to terminate my participation at any time.

(e) I understand that my data and answers to any questions will remain completely confidential. My identity will be withheld from data files, sheets, and analyzes because a number coding system will be used. Only grouped data will be reported in any future publication.

I have read and/or discussed the procedure described above and I understand the procedure. I voluntarily agree to participate in this experiment and I certify that I have received a copy of this description:

____________________________ ________________

____

Signature of Subject Date

Age

____________________________ ________________

Signature of Witness Date

I have defined and fully explained this study to the above named subject:

____________________________ ________________

Signature of Principal Investigator Date

APPENDIX B
A DEMOGRAPHIC QUESTIONNAIRE FOR EXPERIMENT 1

Pre-Experimental Questionnaire

Subject Code___________ (For experimenter use only)

Date____________________

Age_____________________

Year in School_________

Sex (M or F)___________

(1) Are you right-handed or left-handed?_________

(2) Is your vision 20/20?_____ Do you wear glasses/contacts?______

APPENDIX C
A COMPLETE SET OF INSTRUCTIONS FOR EXPERIMENT 1

General Instructions for the Ball-Throwing Task

Thank you for participating in this study. This research is being carried out in the Motor Behavior Laboratory, located in the Center for Exercise Science.

The Center for Exercise Science is a newly established program and laboratory at the University of Florida, located in Florida Gymnasium. The Center is multi-disciplinary in nature, primarily involving the Department of Exercise and Sport Sciences of the College of Health and Human Performance, and the College of Medicine at the University of Florida. The general purpose of the center is to develop an outstanding exercise science research program in order to study the comprehensive effect of various variables on the human body.

This particular tape is designed to provide you information about the task that you are about to attempt. Please pay attention to the taped material.

You are currently seated in front of a task that was designed to record the accuracy that a projectile (ball) has when aimed at the center of this target. As you can see, this target resembles most typical targets that use a bull's-eye for the best score. Objects that hit further away from the center of the target are assigned lower score values, with the best value being a direct hit in the center of the target. This target is mounted on a 4 x 4 foot square board. The 3 x 3 foot blue background was shaped for contrast. This target task has been devised to make the scoring process easier and more exact by removing the chance for human errors. Scoring is accomplished through the use of electrical circuitry and real time data is stored on computer disc for future reference.

The scoring process works in the following manner. As a ball makes contact with the target, small wires are depressed against the metallic backboard, thus making a complete circuit and indicating a specific point value for a "hit" in that area of the target. Once the wire has contacted the backboard surface, it will return to the original position breaking the circuit. The wires are held in place by a nonconductive solakun glue, and are arranged in a progression of concentric circles beginning at a center and progressing outward with each wire places to approximately 3/4 of an inch from the previous wire. This target has a bull's-eye and concentric wires that covered the target area.

Another important aspect of this task can be related to the function of the computer. Not only is the computer capable of storing data for future years, but it also manages the task. The computer is programmed to record data obtained only during certain intervals.

The computer will automatically indicate the proper time to execute the skill and also keep track on the numbers of trials completed by each subject. In addition, the computer is quickly reprogrammed to change the numbers of trials or the allowed time of making a throw at the target.

Now, the experimenter will demonstrate the throwing task and explain the procedures you are required to follow in this experiment.

Do you have any questions?

Specific Instructions for the Awareness Group

The ability to "feel" our movements during execution of a movement act is one of the processes which assists us to control our actions. Information about what the body parts are doing is provided by specific receptors which are located in the muscles, tendons, joints, and on the surface of the skin. When performing a movement skill, you are able to use this information to learn how to improve your performance.

When throwing the ball at the target, try to gain a sense of awareness of the ball. Attend to the way you hold the ball each time you throw it at the target. Feel the shape, size, elasticity, and weight of the ball.

Look at the target board, wires, and the blue background. (Do it now.) Pay attention to the way the wires are structured on the board. How many wires are located at the board? Is the distance among the wires equal? What is the color of the center of the target? Is it blue? Is it dark?

Be aware of the distance between you and the target, and to the direction, velocity, and acceleration of your hand movements to perform accurately. Feel the position of your joints (such as your elbow and wrist) and muscle tension. When performing this throwing task, focus attention on the specific elements of your movements, such as the amount of force your hand generates each time you throw the ball or the way your fingers hold it.

Be aware of the noise generated by the target each time you throw the ball, and be aware of the noise generated by the floor each time the ball is bounced. Develop a feeling of rhythm. Try to feel the initiation and termination of each movement.

Conscious attention to these cues will allow you to control your movements smoothly. Remember, focusing attention on the specific movements required in the task should result in a better performance each time you attempt the task.

Reminder: Every 10 trials the experimenter will remind subjects to "feel your movements, attend to details, and be aware of developing a rhythm to perform the task accurately as possible".

Specific Instructions for the Nonawareness Group

When skilled athletes are asked what they think about during their performance, they typically report that after initiating the first step, the body takes over and everything becomes automatic. They relax their mind and seem to automatically execute the desired movements. Putting it simply, "things just seem to happen."

During this throwing task, we would like you to have the same feeling. Try not to think about what you are doing. Preplan your action. Let your dominant hand automatically throw the ball as fast and accurately as you can without attending to specific details. (Do it now.)

Try to focus on the same point on the target each time (identify a convenient cue), and do not focus on what you are doing. Let the movement flow. Trust yourself, relax, and perform as if in a state of automaticity. Remember, if you are able to follow these specific instructions, you should do well in this task.

Reminder: Every 10 trials the experimenter will remind subjects to "relax, focus on a cue on the target board, and perform as if in a state of automaticity".

Specific Instructions for the Control Group

As you have seen so far, you are going to perform a throwing task that will require you to bounce the ball before it hits the target. You are asked to throw the ball each time that the green light comes on. Pick up only one ball each time you perform the task. Remember, the apparatus is connected to the computer which automatically records your performance.

You were chosen to participate in this experiment because one of our purposes is to collect data on students at college. Such data will help us to understand how people learn motor learning tasks.

Thank you for your cooperation.

Reminder: Every 10 trials the experimenter will remind subjects to "do your best".

APPENDIX D
FIVE-STEP STRATEGY FOR EXPERIMENT 1

Five-Step Strategy

I am going to present you with a strategy which should improve your performance in various movement activities and sports in which you have time to prepare yourself and react. When everything in the situation is stable, you can use this strategy. Examples of such activities and sports are serving a tennis ball, serving in volleyball, shooting a free throw in basketball, hitting a golf ball, diving, bowling, or any other self-paced activity.

The strategy contains five sequential steps. They are as follows:

Readying - Imaging - Focusing - Executing - Evaluating.

The first step is readying. Readiness is a very important first step in achieving in every self-paced task or sport skill. How well you prepare yourself will influence how well you do. The following considerations are necessary in this preparatory stage.

First, get yourself physically comfortable. Your body should be in a position that is most comfortable for you. When you are happy with one position try to repeat it exactly each time you are in the same situation.

Next, get into the right attitudinal and emotional state to do well each time you attempt the activity. An optimal motivational level will also contribute to a good performance.

Sometimes you are unmotivated to perform well in an activity, and the result will probably be poor performance. In order to maintain an optimal motivational level for the activity, try to set a reasonable, attainable goal for yourself prior to each attempt.

Sometimes before performing an activity, you are so aroused that you have anxiety. Anxiety will inhibit your performance. I would like to suggest that you try a relaxation technique if you feel yourself getting tense.

A common relaxation technique is to concentrate on your breathing. Take deep, slow breaths. Inhale through your nose, exhale through you mouth. Feel the tension and anxiety flow from your body and mind as you exhale. Fill your mind with positive thoughts. Say to yourself, "I will be successful."

Inhale, exhale. Feel the tension flow from your body. Say to yourself, "I will be successful." Try this technique for a few moments. (Silence momentarily.) Before performing, try to recall what you did and how you felt at the preparatory stage of your best previous effort. Then, try to duplicate your feelings and thoughts.

Try to be consistent in attaining the preparatory state. Get your body comfortable, set a goal for yourself, relax if you need to, and fill your mind with positive thoughts.

The second step of the strategy is imaging. In this step, you are to mentally picture yourself performing the act briefly as to how it should be done. Try to feel the movement. Please try the following suggestions.

First, let's learn how to image to get the mental picture of an object. Mentally picture a familiar object. How about a blackboard eraser? Create an image of an eraser in your mind for a few seconds. (Silence.) Now, try to picture the details, such as the texture, size, and color. Feel the texture. (Silence.) Now, we are going to add movement. We are going to throw the eraser into a bucket.

1. Picture a bucket that is three feet away from you. (Silence.)
2. Picture yourself tossing the eraser into the bucket. (Silence.)
3. Picture the flight of the eraser. (Silence.)
4. Picture your throwing movement and try to feel it at the same time.
   (Silence.)

Do you mentally see a clear picture?

Please repeat imaging steps 1-4 five times. (Silence.)

Next, choose any activity you prefer and mentally picture the same sequence of operations as you did in throwing the eraser into the bucket. Repeat it five times. Please turn off the recorder and turn it back on to play when you have completed the procedure.

Were you able to form a clear picture?

Were you able to form a clear picture in your mind of the activity that you were doing?

The third step of the strategy is focusing. There are typically many irrelevant cues and thoughts involved in performing any activity. Examples are the background of a particular area in which you are undertaking an activity, noise around you, and thoughts pertaining to not doing well.

To concentrate or focus completely on the skill you are trying to learn, two procedures are required. They involve first attending to your internal feelings or thoughts, and then attending to one external relevant feature of a sport skill or activity.

Attending to your internal feelings is known as centering. Centering involves learning to direct your thoughts toward the center of gravity in your own body. The center of gravity is a point just behind your navel.

Please concentrate on this point of your body. Now, take three full breaths of air while concentrating on this point.

Inhale from your abdomen, not from your chest, as you exhale, consciously relax the muscles in your arms, legs, and neck.

Inhale...Exhale...Inhale...Exhale...Inhale...Exhale.

Are your muscles relaxed?

Are you centered internally? Once you are centered, the next step of focusing is concentrating on one external relevant feature of the activity or sport such as the seams of the tennis ball to be hit in a tennis serve, the center of the target in archery shooting, or the rim of a basket in basketball.

Think only of this cue, which will block out all other thoughts. (Silence.) Let's try to focus on an appropriate cue of a simple task such as throwing a blackboard eraser into a bucket 3 feet away from you. Please do as follows:

First, concentrate only on the opening of the bucket.

Try as hard as possible to focus on it.

Do not think of anything but this portion of the bucket.

You should be focused on the task and ready to perform well. The next step is to execute which is the fourth step of the strategy.

After you are completely focused, you are ready to perform the act. In this step, you will do as follows:

Do it.

Do not think of anything about the act itself or the possible outcome.

Perform as if you received the movement command from your body, not from your mind.

Do not think about the movement.

Do not think about the outcome of the movement.

Keep your sight on your focus point.

(Silence.)

After you have completed the movement, the fifth step of the strategy is evaluating.

In this step you should use available feedback information from the movement to assess the performance outcome and effectiveness.

Adjust any procedure next time if necessary.

Try and use any type of information to adjust your movement or the strategy which will help you to perform better.

Remember, the 5-step strategy was developed to perform your performance in self-paced activities.

Once again, the 5 steps are:

Readying, get yourself optimally ready to perform, physically and mentally. Be consistent in attaining your preparatory state.

Imaging, mentally picture yourself performing the activity. Feel the movement.

Focusing, concentrate intensively on one relevant feature of activity. Block out all other thoughts.

Execute, perform the task. Do not think of anything. Perform with a clear mind. Do not think about the act itself or the possible outcomes.

Then, evaluate, use available feedback. Asses the performance outcome in each step of the routine. Adjust any procedures if needed.

The 5-step strategy:

Step one: Ready
Step two: Image
Step three: Focus
Step four: Execute
Step five: Evaluate.

APPENDIX E
A LIST OF THE 50 PRESENTED SEQUENCES FOR THE VERBAL TASK IN THE DUAL-TASK PERFORMANCE SITUATION FOR EXPERIMENT 1

A List of Sequences

Subject Code:___________

The presented sequence	The number to be named
1 2 3 4 5	# 2
6 8 3 1 2	# 5
3 1 9 8 8	# 3
4 7 1 3 4	# 1
3 6 4 1 2	# 4
7 6 7 4 5	# 1
9 1 7 2 8	# 5
5 2 9 3 7	# 3
4 1 8 5 1	# 4
9 7 3 9 8	# 4
4 7 3 2 1	# 2
2 2 7 9 4	# 1
4 8 2 1 7	# 3
2 6 6 8 6	# 5
5 4 9 1 3	# 2
3 3 9 9 6	# 4
7 1 2 6 8	# 4
5 6 4 2 2	# 1
2 1 9 7 1	# 3
6 4 6 2 5	# 2
5 2 8 4 1	# 3
6 3 2 9 1	# 1
4 2 7 6 3	# 4

8 4 3 7 7	# 2
9 9 5 1 3	# 5
7 4 9 6 7	# 4
5 7 1 8 2	# 2
3 1 1 6 5	# 1
2 6 3 8 2	# 1
1 7 4 8 2	# 5
5 3 9 2 1	# 2
9 6 7 4 4	# 3
3 7 8 2 8	# 3
9 3 2 5 4	# 1
8 4 3 7 6	# 4
2 9 9 2 4	# 5
1 1 8 4 6	# 2
6 5 2 1 8	# 1
4 8 9 1 2	# 3
3 7 9 1 8	# 4
7 1 2 4 1	# 2
4 1 6 9 5	# 2
8 2 9 7 3	# 1
9 3 8 1 2	# 4
3 1 5 8 6	# 2
6 2 8 1 5	# 3
3 7 1 8 2	# 5
2 6 1 7 4	# 1
1 6 6 2 3	# 3

5 8 3 3 2 # 4

APPENDIX F
A POST-EXPERIMENTAL QUESTIONNAIRE FOR CONTROL AND EXPERIMENTAL GROUPS IN EXPERIMENT 1

Post-Experimental Questionnaire
(For Control Group)

Subject Code________________ Date___________

(1) What kind of technique did you use to help you perform the task?

(2) What percentage of the trials do you think you used the above technique?

Post-Experimental Questionnaire
(For Experimental Groups)

Subject Code__________________ Date______________

(1) Did you use the specific instructions to help you perform the task?

(2) If you did not use the specific instructions, then what kind of techniques did you use to help you perform the task?

APPENDIX G
A COMPLETE SET OF INSTRUCTIONS FOR EXPERIMENT 2

General Instructions for the Key-Pressing Task

Welcome to our key pressing experiment. Make yourself comfortable while you look over the key press apparatus. It contains a center key with six keys around it.

You are going to learn to perform a task that will require you to (1) remember a sequence of eight numbers that are associated with six keys (1-6) and (2) depress the keys in the order of the numbered sequence. The sequence of numbers is presented only during practice trials. For example, if the sequence was 1, 2, 3, 4, 5, 6, 1, 2, then you should press the numbered keys in the specified order.

A trial starts when the word "Ready" appears in the center of the screen. When "Ready" is presented, you should place the index and middle fingers (held together) of your dominant hand on the key in the center of the circle. After short delay, "Ready" is replaced with the word "Go." Upon presentation of "Go", you should press the key down in the center of the circle as quickly as possible and then press the eight keys within 2500 milliseconds. You are to attempt to complete this key-pressing task in a time not longer than 2.5 seconds. This time should be your goal. Later you will have practice so that you can get a better idea about the task and the 2500 milliseconds duration. Try to press the keys in sequence at a reasonably fast speed that will enable you complete a trial in the time allotment.

Once you have completed a trial, look at the screen.

The screen will display three lines of information. The top line will be the correct order of key presses you should have made. The second line will be the sequence of keys that you actually pressed on that trial. Ideally, the first two lines should be identical. Response time will be displayed on the third line. This time represents the milliseconds of elapsed time from when the center key was pressed to when the last key was pressed. For example, 1,700 milliseconds means that it took 1.7 seconds to complete the task. When the time displayed will be in red, it means that your performance was longer than the desired time (2500 milliseconds). The four lines of information help to know how you are progressing on each trial, and what you might want to try to improve upon. When you see the next "Ready" signal, you should place your index and middle fingers on the key in the center of the circle and be prepared to depress the key quickly when the signal appears.

Ten practice trials will be given before the experiment begins. At that point, the testing session will begin.

Specific Instructions for the Awareness Group

The ability to "feel" our movements during execution of a movement act is one of the processes which assists us to control our actions. Information about what the body parts are doing is provided by specific receptors which are located in the muscles, tendons, joints, and on the surface of the skin. When performing a movement skill, you are able to use this information to learn how to improve your performance.

When pressing the keys, try to gain a sense of awareness of each key. Attend to the way you press the keys, and the way you shift your fingers from key to key. Feel the shape, size, and location of each key. (Look at the board now and 'study' the keys.)

Be aware of the of the distance among the eight keys and to the velocity, acceleration, and direction of your hand movements to perform rapidly and accurately. Feel the position of your joints (such as your elbow) and muscle tension. When performing this key-pressing task, focus your attention on the specific elements of your movement, such as the amount of force your fingers generate each time you press the keys or the way you touch the keys with your index and middle fingers. Develop a rhythm for pressing the keys, to feel the initiation and termination of each movement.

Conscious attention to these cues will help you to control your movements smoothly. Remember, focusing attention on the specific movements required in the task should result in better performance each trial.

Reminder: Every 10 trials the experimenter will remind subjects to "feel your movements, attend to details, and be aware of developing a rhythm to perform the task as accurately as possible".

Specific Instructions for the Nonawareness Group

When skilled athletes are asked what they think about during their performance, they typically report that after initiating the first part of a movement, the body takes over and everything becomes automatic. They relax their mind and seem to automatically execute the desired movements. Putting it simply, "things seem to happen."

During this key-pressing task, we would like you to have the same feeling. Try not to think about what you are doing. Preplan your actions. Let your dominant hand shift from key to key as fast and accurately as you can without attending to specific details. Create a brief correct mental picture of the screen and keys in your mind immediately prior to performance. (Do it now.)

Try to focus on the same point on the screen each time (identify a convenient cue), and do not focus on what you are doing. Let the movements flow. Trust yourself, relax and perform as if in a state of automaticity. Remember, following these specific instructions should result in better performance each trial.

Do you have any questions?

Would you like to read the instructions again?
if yes, press "1", and if no, press "2" on the next screen.

Reminder: Every 10 trials the experimenter will remind subjects to "relax, focus on a cue on the screen, trust yourself, and perform as if in a state of automaticity".

Specific Instructions for the Control Group

As you have seen so far, you are going to perform a task that will require you to (1) remember a sequence of eight numbers that are associated with six keys (1-6) and (2) depress the keys in the order of the numbered sequence. The six keys are mounted on a wooden box with the face tilted about 29° and are arranged in a circle around a central key. The apparatus is connected to the computer which automatically records your performance.

You were chosen to participate in this experiment because one of our purposes is to collect data on students at college level. Such data will help us to understand how people learn motor learning tasks involving speed and accuracy.

Thank you for your cooperation.

Do you have any questions?

Would you like to read the instructions again? If yes, press "1", and if no, press "2" on the next screen.

Reminder: Every 10 trials the experimenter will remind subjects to "do your best".

APPENDIX H
THE QMI QUESTIONNAIRE

QMI Scale

Instructions: The aim of this test is to determine the vividness of your imagery. The items on the test will bring certain images to your mind. You are to rate the vividness of each image by reference to the accompanying rating scale, which is shown below. For example, if your image is 'vague and dim' you should give it a rating of 5. Record your answer by darkening the circle under the corresponding number on your answer sheet. Before you turn to the items on the other side of this page, familiarize yourself with the different categories on the rating scale. Throughout the test, refer to the rating scale when judging the vividness of each image.

The image aroused by an item on this test may be

Rating 1 - Perfectly clear and as vivid as the actual experience.

Rating 2 - Very clear and comparable in vividness to the actual experience.

Rating 3 - Moderately clear and vivid.

Rating 4 - Not clear or vivid, but recognizable.

Rating 5 - Vague and dim.

Rating 6 - So vague and dim as to be hardly discernible.

Rating 7 - No image present at all, you only 'know' that you are thinking of the object.

An example of an item on the test would be one which asks you to consider an image which comes to your mind's eye of a red apple. If your visual image was moderately clear and vivid you would check the rating scale and then darken the circle with the corresponding number on your answer sheet.

Item:	1	2	3	4	5	6	7
5. A red apple	○	○	○	○	○	○	○

Now, turn over this sheet when you have understood these instructions, and begin the test.

Rating 1 - Perfectly clear and as vivid as the actual experience.

Rating 2 - Very clear and comparable in vividness to the actual experience.

Rating 3 - Moderately clear and vivid.

Rating 4 - Not clear or vivid, but recognizable.

Rating 5 - Vague and dim.

Rating 6 - So vague and dim as to be hardly discernible.

Rating 7 - No image present at all, you only 'know' that you are thinking of the object.

Think of a relative or friend whom you frequently see, and classify the images using the rating scale.

1. The exact contour of face, head, shoulders, and body.
2. Characteristic poses of head, attitudes of body, etc.
3. The precise carriage, length of step, etc., in walking.
4. The different colors worn in some familiar costume.

Think of seeing the following, and classify the image using the rating scale.

5. The sun as it is sinking below the horizon.

Think of each of the following sounds, and classify the image using the rating scale.

6. The whistle of a locomotive
7. The honk of an automobile
8. The mewing of a cat
9. The sound of escaping steam
10. The clapping of hands in applause

Think of touching each of the following, and classify the images using the rating scale.

11. Sand
12. Linen
13. Fur
14. The prick of a pin
15. The warmth of a tepid bath

Think of performing each of the following acts, and classify the images using the rating scale.

16. Running upstairs
17. Springing across a gutter
18. Drawing a circle on paper
19. Reaching up to a high shelf

20. Kicking something out of your way

Think of tasting each of the following, and classify the images using the rating scale.

21. Salt

22. Granulated (white) sugar

23. Oranges

24. Jelly

25. Your favorite soup

Think of smelling each of the following, and classify the images using the rating scale.

26. An ill-ventilated room

27. Cooking cabbage

28. Roast beef

29. Fresh paint

30. New leather

Think of each of the following sensations, and classify the images using the rating scale.

31. Fatigue

32. Hunger

33. A sore throat

34. Drowsiness

35. Feeling full after a large meal

APPENDIX I
A LIST OF THE 50 PRESENTED SEQUENCES FOR THE VERBAL TASK IN THE DUAL-TASK PERFORMANCE SITUATION FOR EXPERIMENT 2

A List of Sequences

1 Q W Y T J N

2 K E W B N S

3 Y S P F X H

4 W Z L S J B

5 Y P B H W R

6 P S O I G X

7 W S F N J K

8 B K S A R Q

9 E H D N A M

10 L J W H T E

11 L Z C K I G

12 G I M J B C

13 A K N O B H

14 Z R T G Q P

15 Z N X B O L

16 H I P W Q P

17 Q S E N F W

18 Q O B K X N

19 E S C G N O

20 L W N K R Q

21 Y X S C K Z

22 T P R G J F

23 W O F G M T

24 G F L I O P

25 M S H D T K

26 M A E H Z J

27 G S T D X B

28 A L H J N W

29 A N O S P D

30 M N B P I R

31 J M R N F Z

32 R F W S Y L

33 R N Y C M Q

34 Z H T C Q F

35 Y W M O I T

36 T N A I Y S

37 K N S P X Q

38 Y G B W P R

39 N K M H F I

40 M R T O Q I

41 Q J B G O F

42 F Z T W H S

43 P T M F Q B

44 R S O W I T

45 S W R M Z X

46 B L D M E T

47 Q Z B W P O

48 T C Y P D F

49 Q C T S F M

50 G F T S K Y

BIOGRAPHICAL SKETCH

Ronnie Lidor was born in Tel-Aviv, Israel on February 1, 1960. He attended Irony Hay High School in Tel-Aviv and received his high school diploma in 1978. He was awarded the bachelor's degree in physical education from Zinman College at Wingate Institute in 1984.

After three years of working for Zinman College as a physical education instructor and coaching basketball in the first (as assistant coach) and second (as head coach) divisions in the Israeli league, Ronnie Lidor resumed his education. He entered the graduate program in human performance at Boston University, and received his M.A in August, 1987. Upon graduation, he enrolled at the University of Florida in the motor behavior program. He specialized in motor learning, motor control, and sport psychology, and was awarded the Ph.D degree in December, 1991.

Upon completion of the Doctor of Philosophy, Mr. Lidor has accepted a position in the Zinman College of Physical Education, Nethanya, Israel.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert N. Singer, Chair
Professor of Exercise and Sport
Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James H. Cauraugh

James H. Cauraugh, Cochair
Associate Professor of Exercise
and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

L. Keith Tennant
Associate Professor of Exercise
and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Milledge Murphey
Associate Professor of Exercise
and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Peter J. Lang
Graduate Research Professor of
Clinical and Health Psychology

This dissertation was submitted to the Graduate Faculty of the College of Health and Human Performance and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1991

Dean, College of Health
and Human Performance

Dean, Graduate School